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Journal

—OF THE—

American Ceramic Society

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries.

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JOURNAL
OF THE
AMERICAN CERAMIC SOCIETY

A monthly journal devoted to the arts and sciences related to the silicate industries.

Vol. 1 **August, 1918** **No. 8**

EDITORIALS.

THE ANNUAL MEETING.

The decision of the Board of Trustees to hold the next annual meeting in Pittsburgh on February 3rd, 4th and 5th appears to be a logical one from every viewpoint. Pittsburgh is centrally located, not only as regards railroad facilities, but particularly as regards the distribution of the members of the American Ceramic Society. The meeting should, therefore, be unusually well attended as have those which have been held in Pittsburgh or vicinity in the past.

It is to be hoped that the appeal of the Program Committee for papers to be presented at this meeting will meet with a gratifying response from the membership of the Society. It is to be particularly hoped that our newer members will come to the front and do their share in making this meeting a banner one.

Although our membership has largely increased during the past two years, it will not be an easy task to produce the quantity of high-class contributions necessary for the program of this meeting. When we consider that most of our Government and University laboratories have devoted a large part of their attention to the solution of the numerous War problems which have arisen, and that many of our investigators have been in the Service, we are convinced that unusual efforts will be necessary to bring out the papers for this meeting. The readjustments necessary in many of the Ceramic industries have not been conducive to careful and exhaustive researches of a peace time nature.

It behooves every member of the Society to exert himself in soliciting and producing contributions for the program of this meeting.

TO OUR MEMBERS.

For Americans, November eleventh, 1918, was a far more eventful day and a day fraught with far more radical change in the order of everything than was April 6, 1917.

War, preparation for war and prosecution of war demanded much of all of us, and particularly did it demand a quick adjustment or sudden abandonment of manufacturing, all for a definitely known purpose, and to a definitely known result.

We are now faced by Reconstruction: What of labor, money, prices, etc.? Will freight rates limit or prohibit sources of supplies and markets for manufactured goods?

We do know that our boys are coming back, most of them immediately—our transportation facilities will be required less and less for troops and munitions. We now have better equipped rail facilities and a growing merchant marine, all of which spells Prosperity. None can see and only a few—a very few—dare predict when, or how the prosperity will come. Rumors of prosperity and of depression are deductions from the same data and conditions, and by equally well posted minds.

These things are sure; Americans, individually and collectively, have more money, are more optimistic, have more resources, and have learned the value of preparedness so—Now that the Governmental restrictions and guidance, and committee interference are no more, each individual and concern must again gird for competition. The clarion call for Ceramic workers is to Organize—Organize—for all purposes but in no other as much as for strength technically.

As sure as the seas are now wide open and traversed by hundreds of more freighters, so surely will competition be more keen. War found us unprepared—behind the times. We caught up—but was it not most largely because of pooled interests and federal guidance? Will Reconstruction find us unprepared?

The American Ceramic Society has gone a long way on the necessary road to preparedness by the several changes in rules,

establishment of Local Sections, publication of a Journal, but it must go much farther. We must organize the Professional Divisions at once and make a drive for new members. We must have more contributions to our literature—both practical and technical. We must have more coöperation with other scientific societies.

Now all boost—get together—bring in your neighbors that we, united in one for effective team work, may the better and the quicker prepare for the technical demands of a world-wide competition. The Society is yours and the officers are your servants —write to them your ideas—contribute to the JOURNAL—and be sure to remember that your Society—your Organized Technical Preparedness Effort—needs the Contributing Membership of your firm and Associate Membership of your fellow-worker.

BOOST! for Prosperity is here.

ROSS C. PURDY,
Chairman of Membership Committee.

DIRECTORY OF DEALERS.

Attention is called to the advertisement on another page of the "Directory of Dealers in Raw Ceramic Materials," published by the American Ceramic Society.

This pamphlet was compiled by the Sub-Committee on Clays and Raw Materials for the Clay Industry, and contains the names of 671 firms dealing in kaolins, ball clays, flint, feldspar, plastic and flint fire-clays, limes, etc. These are listed in two ways; first, the firms are placed alphabetically, with the chief materials carried by each; second, the materials are arranged alphabetically and the firms from whom they may be obtained are, listed under each. There is a supplementary list of special glaze and body materials, with the names of the dealers carrying them.

The bulletin is comprehensive and will be valuable to those who buy the various raw materials of the ceramic industry.

ORIGINAL PAPERS AND DISCUSSIONS.

NEWCOMB POTTERY.

I. HISTORY OF NEWCOMB POTTERY.

By Mary G. Sheerer.

The Newcomb Pottery was started through a desire of the Art Department of Newcomb College to provide a means of bringing the work of its graduate students before the public. There was little or no opportunity in the South at that time (1894–5), for these students except to teach, so the Department undertook to make a way for them.

The governing motive of the Newcomb Art School has been to bring art into every phase of life; not to confine it to the teaching of picture making, or statuary, but to connect it as well with household furnishings, such as pottery, china, textile decorations, book-binding, jewelry, etc.

In 1885 an art leagure was formed in New Orleans under the supervision of Wm. Wordwerd, professor of art at Tulane University. The league conducted a pottery for five years and many very creditable pieces came from its kilns, but, owing to lack of capital, it was unable to continue. Like so many other efforts which seem to fail, however, it proved to be the suggestion for the more substantially planned pottery which followed it some five years later at Newcomb.

Active experiments were begun in October, 1895. In one end of a large room was built a round kiln with four fire boxes. There were in the same room a kick-wheel, drying shelves, tubs for clay, tables, decorator's working outfits, exhibition shelves and tables, glaze pots and a hand-mill for grinding. No tenement room was ever used for so many purposes, but there

FIG. 1.—First home of Newcomb Pottery.

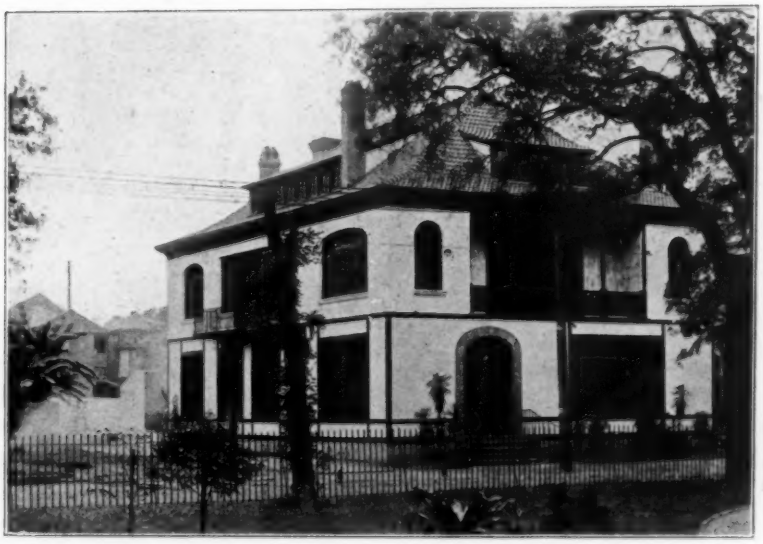


FIG. 2.—Present home of Newcomb Pottery.

was interest, enthusiasm, and activity aplenty—and great expectations!

The services of a potter from the Golf Juan Pottery at Cannes, France, were secured and to him was entrusted the making of forms on the wheel, glazing and firing.

The writer came from the Cincinnati Art School to conduct classes in the decoration of pottery and its appreciation. The president of the College, and the director of the Art School with the well-equipped students from the Newcomb Art School, completed the personnel of the pottery force.

A cream colored clay and a red clay, locally procured, were washed by hand in tubs. Clear glazes, from French recipes, were ground in a hand-mill and experiments were made on both both clays by slip painting, biscuit painting, inlaying and modeling. From a sample collection of underglaze colors, two blues, a green and a yellow were selected. Considerable work was done with slip painting, entire back-grounds being put on by spraying with a cup atomizer.

Design was such a strong feature at the Art School that the

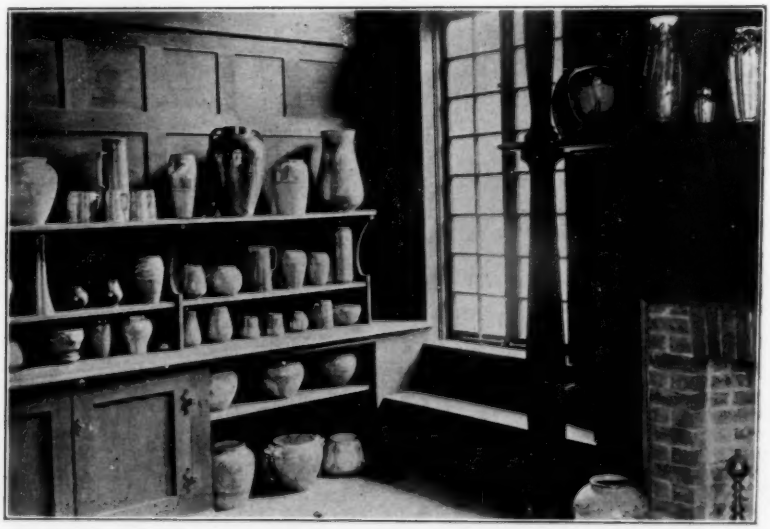


FIG. 3.—Corner of present salesroom.

decoration was mainly simple and good from the beginning, but slip painting was found difficult to control in this warm climate where the windows and draughts are many, so it was soon abolished in favor of biscuit painting.

The character of the decoration came about through a natural growth. After abandoning slip painting the designs were drawn and painted on the biscuit. After unsuccessful attempts to secure the desired texture on the clay surface as it came from the wheel, it was decided to produce the texture with the sponge on the green or unfired piece. This led to designing on the wet clay and incising the designs and painting after the first fire. This gave more variety and depth to the effect and the method still continues in use.

The last few years have seen a marked growth ofi nterest in the hand-built pottery. The personal touch and variety of surface which these pieces afford give added charm to the glaze and no decoration of the form is needed.

A matt glaze which is used on this ware has a wide range and is good in texture. Following is its formula and also that of a tin glaze used:

MATT GLAZE

$$\left.\begin{matrix}0.6\ PbO\\0.4\ CaO\end{matrix}\right\}\ 0.35\ Al_2O_3\ \left\{\ 1.00\ SiO_2\right.$$

TIN GLAZE

$$\left.\begin{matrix}0.7\ PbO\\0.2\ CaO\\0.1\ ZnO\end{matrix}\right\}\ 0.15\ Al_2O_3\ \left\{\begin{matrix}1.75\ SiO_2\\0.3\ \ SnO_2\end{matrix}\right.$$

II. TECHNICAL PRACTICE AT THE NEWCOMB POTTERY.

BY PAUL E. COX.

Introduction.

In view of the fact that the Newcomb Pottery will be moved to new quarters sometime during this year, it seems fitting that this termination of what might be called the "second period of the life of Newcomb Pottery" be marked by a report of the technical development to the present time.

The writer believes that Newcomb Pottery has been bettered and that the reputation of the pottery as an art product has been enhanced by the application of the principles taught in the ceramic schools, and that an art pottery is great only when it recognizes

that technical merit is a close second to good design in decoration, or good taste in choice of coloring, and that a leaky, badly glazed and fired vase, no matter how perfect the design or how lovely the coloring, is bad and unworthy of a place of merit. This refers, of course, only to contemporary pottery, since there is no excuse for anything to the contrary being made in the light of our present knowledge.

Body Mixtures.—The body in use at Newcomb Pottery eight years ago was reported as made of a mixture of Biloxi clays Nos. 1 and 2, Iuka clay, Texas kaolin, and feldspar. The Biloxi clays were secured from a bluff close to Biloxi, Miss., and were reached by a schooner working its way up the bayou on which the clay was found. These clays had been used locally by flower-pot and charcoal makers and were also rather excellent for the purposes of pottery making, but were not easily accessible—since there was little method in handling the overburden of the deposit and a large amount of waste material was necessarily removed each time clay was taken out. As a consequence, when opportunity offered a clay that was more easily obtained, a change was made.

The body made from the above clay mixture was covered with a clear glaze and fired at between cones 02 and 1. The ware was porous, crazed badly, and had little to recommend it except that the body was easily worked on the wheel and in the class rooms.

Since Newcomb Pottery is indigenous to Louisiana in decoration and spirit, it was desirable that the clay be obtained in Louisiana. Samples of clay from Covington, a point across the river in St. Tammany Parish, close to the city of New Orleans, proved workable and the body as now used is composed as follows: 35 per cent Covington clay, 45 per cent Paducah ball-clay, and 20 per cent feldspar. The Paducah ball-clay was chosen only because it gave satisfaction and was easily obtained. It might be replaced by other light-burning clays.

The above body burns dense at between cones 3 and 5 (the cones used), and works well on the wheel—though a little contrary for large pieces—does not leak when fired even a little soft,

and the glazes stand well without crazing. The decoration being put on by cutting away part of the clay, the mixture must be well lawned and free from grit in order to secure good results. Since a thorough sponging of the surface is made by the designer for the sake of the proper texture for the later painting, there must be little washing away of the clay in the process. The above body was developed with these objects in view and has proven successful.

According to the writer's observations of the tests of different clays on the wheel by the very skillful throwers working at Newcomb Pottery, coupled with tests by himself on the wheel, he is inclined to question whether or not a satisfactory definition of plasticity has ever been made. The clay in use at Newcomb Pottery would usually be rated as a very plastic one, and yet large pieces are made from it with difficulty because the pieces settle after the first draft is made. On the other hand, small pieces are made with the utmost facility. Other clays used, one from Fish River, Alabama, for example, are not open to the same criticism, but are worthless for pottery making. Still others are entirely satisfactory in all respects. Tall pieces are made on the wheel more easily from sandy clays than from fat clays. Many very fat clays which have been tested on the wheel could not be thrown at all, but were otherwise of the sort that would be considered plastic. No tests other than wheel tests were ever made.

Preparation of Body.—Owing to the fact that the sand from the very sandy local clays worked back from the end of the shaker lawn and into the lawned slip cistern, and that the lawns wore out so rapidly and at such inopportune times, shaker frames were discarded. A trough was arranged to separate most of the sand by means of a series of baffles and the slip was then poured through the lawn—a single one of 150 mesh. It has been found that better clay and more of it for a given period can be had by this arrangement than with a machine. The Covington clay consists of about one-third white sand, which wears the metal lawns rapidly, so that this seemingly more primitive method is the better one.

From the cistern, the slip is pumped into a 100 gallon tank to which air at 100 pounds pressure is admitted. This tank is connected to the filter press and the air under pressure forces out the water. The writer has found that a compressed air system for pressing clay does away with the nuisance of the overflow valve, presses a more uniform cake of clay without soft centers, is easier on the sacks, and that a press of clay may be made at night while the rest of the machinery is not working.

We have found that there is no need for agitation of the slip in the tank if there is as much clay to keep the inert matter in suspension as there is in this body. Any industry using natural clays can save very largely in installation cost and subsequent repairs by the substitution of a tight tank for the slip cistern and by running the slip by gravity to the tank. No difficulties from sedimentation will be met with—if reasonable care is taken to clear the tank once a week or oftener—and better clay cakes will come from the press. The writer has had a chance to test out many kinds of filter-press sacks and has found that the twilled press sack material, used in most sugar houses, is better than the canvas used in most clay plants. It does not become clogged so quickly and is more easily washed out and does better work in every way.

Molding and Decorating the Ware.—All ware made at Newcomb Pottery is thrown and turned—the same wheel being used for turning as for the throwing.

In a leather-hard condition, the ware goes to the designer, who sketches the design and scrapes and cuts away a part of the clay so that the design is in slight relief. After drying at room temperature, the ware is biscuited to cone 012, and is then painted by the artist who designed it—the colors being underglazes supplied by color dealers. The glaze coating is then put on and the ware fired a second time at between cones 4 and 5.

Glazing.—The inside glaze coating is applied by the use of a pump—since the ware must never be touched on the outside by the fingers. Even the dry clay pieces must not be touched in placing in the biscuit kiln as any finger marks will show. The surface obtained by the sponging process is so delicate that finger

marks are filled in by the wash of blue with which the values are obtained and show in a very unsightly way after the glost fire.

The outside coating of glaze is applied by dipping, the pieces being handled by the bare bottoms and the uncolored rims. The bottoms are then sponged free of glaze, the untouched rim is covered with glaze by means of the air brush, and two coats are added all over with the same air brush.

Several coatings of glaze are applied. By the use of colored dyes, confusion in the glazing is avoided. After applying the first coating a colored (dye) glaze coating is applied to a table full of ware. This is followed by a coating of another color and this provides a standard glaze coat which is free from crawling and gives to the colors put on the values desired by the decorators. Nearly all of the losses are due to too thick glaze coating and even with the system outlined, mistakes in judgment occur.

The glaze now in use has the following formula:

$$\left.\begin{matrix} 0.10\ K_2O \\ 0.50\ CaO \\ 0.40\ PbO \end{matrix}\right\} 0.50\ Al_2O_3 \left\{ 1.40\ SiO_2$$

The dry glaze mixture is ground in the ball-mill with denatured alcohol and then applied with the spray. This glaze does not flow when applied but dries at once and can be handled rather freely. At times, it is desirable to put a coating of colored glaze over a piece that is not so desirable from the standpoint of color and this easy method has saved many a dollar that would have otherwise been lost. By the use of a glaze maturing at a lower temperature, and by grinding in alcohol as indicated, the cooler parts of the kiln are utilized with considerable gain.

In a general way the writer has decided that, whatever the theory under which matt glazes are developed may be, the nature of the body on which they are to be used must be reckoned with and, if a glaze with a wide firing range together with freedom from crazing is desired, the clay content must be high and silica content low. In a general way, our experience at Newcomb Pottery agrees with that of others as to the types of formulas giving the best matt glazes.

It will be noted that the clay content in the above matt glaze

is very high. For a time we used calcined clay and gum of tragacanth in the glaze. The gum proving troublesome, it was eliminated to the advantage of the product. The calcination of the clay was next discontinued and the glaze was found to adhere to the ware better. Difficulties from crawling were overcome by the use of the air brush and a thin first dipping. It is the writer's opinion that there is no reason for the crawling of art pottery glazes, no matter what formula is used, provided the glaze work is given careful attention.

Kilns.—The two kilns are round, down draft, one being 6 feet and the other 5 feet diameter, outside, the larger one taking six and the smaller three bungs of saggers. Each kiln has two fire boxes. An iron case, $^{3}/_{16}''$ thick, encloses the brick work of each and, in order to make wicket building easy, a flat arch tops the doors. The doors are built up of special sagger clay blocks made at the pottery. The flat arches were made by supporting the outside ends of the bricks by a plate of iron, so that only the ends of the bricks are exposed to the high temperatures—the bricks being driven in place tightly and with no mortar.

The smaller kiln is used for biscuit—since the biscuit can be doubled in placing. About four-fifths of the glost kiln produces satisfactory, well-burned ware and the space left is used in a way which will be described later.

Distillate is used for fuel. This is stored in a thousand gallon tank in the pottery yard, the oil being forced to the kiln burners by pressure from a small volume blower which injects the oil into the fire box in a stream from the central tube of the burner. The surrounding tube of the burner furnishes air in a volume sufficient to break the oil into a spray and to furnish much of the air for combustion. The volume blower forces air into the oil storage tank and the air-tube of the burner is connected to a pipe that takes its supply from the storage tank so that the oil tank serves as an air reservoir as well. Pressure of about eight pounds is maintained by the blower. The oil gives little trouble—aside from the deposit of masses of carbon which sometimes divert the path of the flame so that the ware suffers from reduction and blistering. This does not often happen and the losses in the kiln

last year were under three per cent—mostly caused by other reasons than kiln accidents. To burn the two kilns, with an average of 120 pieces in each, requires 150 gallons of distillate costing from $6^1/_2$ to $7^1/_2$ cents per gallon delivered.

Saggers.—For sagger-grog, waste fire brick are crushed in a laboratory crusher. The mixture of raw sagger clay is prepared by washing in a blunger. It is washed as thick as it can be handled in the machine and then poured into a galvanized iron pan resting over a furnace. A coarse screen takes out the bits of clam shell and oyster shell, that cause "poppers" if not removed, and the dry grog is then added. The sagger mixture is as follows:

30 per cent by volume	New Orleans Clay
30 per cent by volume	Biloxi No. 1 Clay
40 per cent by volume	grog

The mixture is ground as stiff as possible in a wet-pan and then wedged by hand.

The New Orleans clay is that deposited by the river and its sand content varies. In the clay state, the saggers stand a great deal of rough handling without damage, due to this gummy New Orleans clay which, when fired, vitrifies so that the saggers are both open and strong. The clay does not burn dense by itself because of its content of sand. Saggers made of the above mixture have been in use from ten to twenty times a year for five years and, in some cases, six years, and are still in excellent condition. The writer feels that this is a better sagger body than is usually met with in this sort of work and under the conditions laid down.

Placing.—The ware is burned in a low biscuit and a high glost fire so that most of the shrinkage takes place in the second fire. Consequently, it is not safe to place the glost pieces on stilts. The glaze is removed from the bottoms of the pieces and—except in the case of pieces with wide bottoms which are not liable to topple over—the pieces are placed on the bottoms of the saggers. Since this is done, the saggers are not glazed inside, as we have found that in a 14-hour burn there is no advantage in so doing, and, furthermore, the glazed saggers have a shorter life. The

bottom of each sagger is coated with a wash of refractory clay and, since the bottoms of the pieces have been cleaned of glaze, little of this adheres to the pieces. This method has almost entirely prevented kiln losses through sticking. It is desirable to have the bottom of a pot glazed, but not desirable enough to risk the loss of a piece after so much work has been done upon it.

One of our sources of loss has been the blistering of pieces exposed to a slight reducing flame and, since the fire boxes are a large part of these small kilns, the saggers are subject to more reduction than they would be in a larger kiln. In case the glaze coating is too thin, the addition of another thin coating will make the piece a choice one. In fact, the best ware is often that which has had a third firing with a thin added coat of glaze. However, there is comparatively little of this sort of work to be done, so that if the piece is valuable the expense is justified.

The work reported in this paper would have been done by any man trained for the job and there is nothing startling to report. However, some others, with the same problems to solve, may find helpful hints. No claim for perfection in methods is made by the writer—this paper merely tells what has been done. Most of the methods followed were make-shift ones, but the Pottery speaks for itself.

NEWCOMB POTTERY,
NEW ORLEANS, LA.

A CONVEYOR STOVE ROOM.

By C. E. Jackson, Wheeling, W. Va.

Much progress has been made in the pottery industry within the last few years and especially in kiln construction. However, very little attention has been paid to one of the most vital departments of a pottery, *viz.*, the clay shop in which all of the ware is formed. We do not believe it possible to change its fundamental or basic operations. We assume that it will always be necessary to use molds made of plaster of paris or of some other material that will give the same result. Therefore, any advancement that can be made in this department will have to be in the simplification of its well-known operations. It was with this object in view that the writer undertook to eliminate some of the trouble that attends the manufacture of goods, generally known as flatwares, and which are made on the machines called jiggers.

It has been the custom to consider the operating jigger unit as consisting of a jigger-man, a batter-out, one or two mold runners, and a stationary stove room. The function of this stove room is to receive the molds on which the ware is formed in the wet state and to give sufficient capacity to retain the same until dry. This means that the size of the stationary stove room is largely governed by the number of molds necessary for the day's operations. Let us assume that this number averages from 175 to 200 dozen per jigger-man—and that the number of stoves in the jiggering department is in proportion to the number of jigger-men.

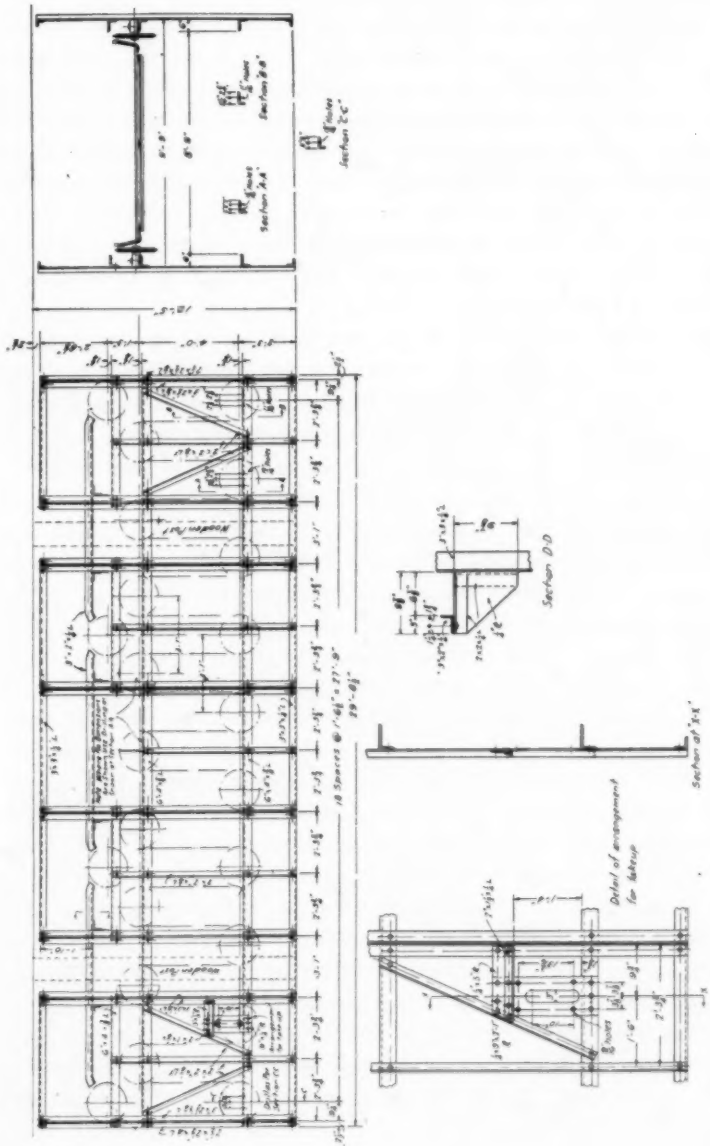
Since the operating unit consists of a jigger-man and two (or in some cases three) male helpers, we will consider an operating unit as consisting of a jigger-man and his attendant labor. The attendant labor has always been the obstacle in the steady production of the jiggering department. It has usually consisted of boys and young men, in most cases irresponsible. When this attendant labor fails to come to work, it means that the output for that operating unit is lost for the day, and this becomes a

constant occurrence. Furthermore, the efforts of the jigger-man, instead of being devoted to the making of the pieces of ware at hand, are largely given to the control of his attendant labor. Owing to the passage of the Child Labor Law in the various states, it became very difficult to obtain this attendant labor, and even more so after we entered the War. Various plans have been suggested and talked over for the elimination of this attendant labor. In Europe, the problem had been partly solved by the use of a bat-making machine, but there still remained the question of getting the molds to and from the stove room which necessitated attendant help for the jigger-man. We endeavored, therefore, to take advantage of the partially worked out system in vogue in Europe, and, by the use of a conveyor operating in conjunction with a bat-making machine, to totally eliminate all attendant labor. The writer is pleased to state that this has been accomplished in a most satisfactory manner.

A conveyor system, consisting of two lengths of chain operating on parallel lines on sprockets, and carrying shelves on which are placed the molds, was designed and constructed. After filling, the molds are placed by the jigger-man on the shelves of the conveyor. A movement of the chain carries the shelves to the rear of the conveyor where they are emptied by the finisher. The empty molds are then returned to the jigger-man for refilling.

In an installation of this kind there are many things to be considered. There is no question that the system requires more space than the old stationary stove room, but in a different manner. The old stationary stove room required considerable space running the length of the shop while the conveyor requires depth or height. By referring to the drawing it will be be noted that the chain travels up and down nine times. We found this travel necessary in order to secure the length of chain required. Had the ceiling been higher, we would have made the conveyor higher and the up and down movements fewer.

Very few potteries present greater obstacles than ours in the establishment of this system. However, it is necessary to understand the fundamental principles of conveying machinery before


Section D-D
Section at X-X
Detail of arrangement for damper

installing the system. The first decision to be made is the number of molds the conveyor is to carry. If the number of dozens of ware per machine per day is decided upon, and the molds are to be filled but once a day, then sufficient chain length to allow the required number of shelves is necessary. However, we must bear in mind that the production per day, using the conveyor type of stove room, will be less than by the use of the old system—owing to the fact that the jigger-man has no attendant labor whatever. We have found the difference to be about 25 per cent. While this is true per day, the number of dozen pieces of ware produced during a period of 30 days will be greater—owing to the fact that a jigger-man will work full time. Using the old stove room, with attendant labor, the efficiency was not more than from 60 to 75 per cent. It is necessary, therefore, to take this into consideration in figuring an installation.

Sufficient heating apparatus is necessary for the drying of the molds and ware in transit. We have found the use of exhaust steam pipes laid on the floor under the conveyor to be the most advantageous. In considering the installation of the steam pipe system, it is necessary to take into account the fact that, on the overhead return of the conveyor, the molds have been emptied by the finisher, which means that only 75 per cent of the molds in the conveyor are actually drying the ware.

The batting-out machine is constructed on the same principle as the spreader—which is nothing more nor less than a flattening-out tool working on a revolving plaster whirler. The jigger-man places a piece of clay of the desired size on the whirler (when stationary) and then throws the machine into gear. The action of the down coming arm forming the bat is automatic with the revolving whirler. After the bat has been made, the arm being released, returns to its original position, the whirler being again stationary. This is all being done while the operator is making a piece of ware. The operator, working at right angles to the machine, lifts the mold out of the jigger-head with the left hand and places it on the conveyor shelf which stands at the level of the jigger box. With the same movement he places another empty mold for filling.

The three mechanical movements necessary, *viz.*, that of the

batting-out machine, the operation of the jigger, and the movement of the conveyor, can all be controlled by one mechanical movement as exemplified in the machine for this purpose placed on the market by the Potters Equipment Co., 200 5th Ave., New York, N. Y. In our case, each unit is operated separately.

Although the action is very simple, the advantages to be gained by this system are: First, the elimination of attendant labor; second; continuity of output; third, the jigger-man has nothing to detract his attention from the work at hand. By its use we find that the drying is more uniform, the production is more uniform from all angles, the ware is of better quality, and there is less loss in our biscuit ware room. Comparing the earning power of the jigger-man against the old method, we find that with the new system, the average earning of the jigger-man is higher by about 10 per cent. We are able to keep our shop much cleaner—which is conducive to the health of the employees. While an equipment of this kind is somewhat expensive, we believe that the advantages to be gained are sufficient to justify the installation.

WARWICK CHINA CO.

PREPARATION AND APPLICATION OF ENAMELS FOR CAST IRON.[1]

By Homer F. Staley, Washington, D. C.

ENAMEL MAKING DEPARTMENT.

The enamel making department, usually known as the "mill room," comprises facilities for storing, weighing and mixing raw chemicals, furnaces for melting the enamels, enamel dryers, and mills for grinding and sifting the enamel.

1. Storing, Weighing and Mixing the Raw Materials.

Of course the relative arrangement of these various parts can be varied at will. A commonly used and convenient arrangement is a three-story building with the melting furnaces at one side or end. The crude raw materials are stored on the third floor. They are sifted there by mechanical riddles and then fed into chutes leading to bins on the second floor. The sifting not only removes any nails, pieces of twine, etc., that may have gotten into the raw materials, but also serves to break up the lumps that commonly form in powdered chemicals. The absence of lumps greatly facilitates the fusion of the enamel to a homogeneous glass.

On the second floor the weighing and mixing of the batches are carried on. In one arrangement the bins are built in a long row with their bottoms a few feet above the floor level. A set of scales on wheels runs on a track in front of this row of bins. The chemicals can be scraped by a hoe as desired from the various bins. Gravity feed of the powdered chemicals into the weighing box has not proven successful. Part of the time they stick and do not feed at all, and the rest of the time they come down with a rush. This system eliminates all shoveling, but entails considerable moving of the scales and partially completed mix back and forth. In another system, the bins are arranged in a circle around the scales. The chemicals can be scraped into the weighing box by means of a hoe and troughs, but often are simply

[1] By permission of the Director, Bureau of Standards.

shoveled in. Multiple-beam scales, weighing at least six ingredients with a single setting, are commonly used.

The mixing of the raw batch should be very thorough. With small batches this is often done by "cutting" the completed mix with shovels. Care should be taken to see that each shovelful of the mix is actually turned over in each of at least three cuttings. After this the whole mix should be run through as fine a riddle as possible. With large batches, mechanical mixers of various types are employed. In general, it may be said that batch mixers are more satisfactory than continuous ones, and that the drum type, in which the whole mix is thrown over and over, is better than the trough type, in which mixing blades travel through the batch lying in a stationary container. In continuous mixers, the portion fed into the machine first comes out first and therefore the batch as a whole is never blended. When dependence is placed on mixing blades in a stationary trough or a fixed container of other shape, a layer next to the shell is not mixed in with the rest.

A simple and efficient batch mixer of the drum type consists of a ball-mill without any balls. A lining is not necessary. If desired, three or four stout bars may be inserted midway between the circumference and axis and extending from one end of the mill to the other. These are not necessary, neither are shelves to carry the mix up the sides of the mill. If a batch, not filling the mill over two-thirds full, is run in a plain ball-mill, without balls, at a proper speed for five minutes, it will be found to be very thoroughly mixed.

A convenient location for the mixer is below the floor level of the weighing floor but above the level of the top of the melting furnaces. If not more than three furnaces are to be fed from one mixer and these are built close together, the material may be dumped into a stationary hopper and fed into the top of the furnace, by spouts. The angle of the feed spouts with the horizontal should be at least 60 degrees. When the material is to be carried a greater distance, a hopper-bottomed car or lorry running over the tops of the furnaces is convenient. The sides of this hopper should also form an angle of at least 60 degrees with the

horizontal. It is too hot on top of a furnace to permit of dislodging material that sticks in a hopper or spout.

2. Melting the Enamel.

Melting Furnaces.—The furnaces used for melting enamel are of the reverberatory type. They are similar to the ordinary potters frit kiln but larger, some of them holding over two tons of melted enamel. They are simply large boxes with inclined bottoms and low arched roofs. The raw material is fed in batches at the top, or side, and drawn off periodically from a tap-hole on one side. Many efforts have been made to operate melting furnaces continuously but without much success up to the present time. The heat is obtained from a flame passing across the kiln just beneath the roof. Various attempts have been made to build frit kilns that would be heated from below, without contact of the combustion gases with the frit, but no material has been found that will transmit the heat readily and yet resist the intense corroding action of the molten frit. In Fig. 1 are shown the drawings of a frit furnace used in several plants. It will be noticed that the arch of this furnace does not drop down as it approaches the end away from the fire. A dropping arch is more expensive to build than a straight one, and proper approach of the flame to the melt can be obtained by regulation of the height of the arch as a whole, the slope of the floor and the outlet of the chimney. In another type of furnace, the position of the melting chamber is reversed from that shown in these drawings, the flame traveling across the short dimension. In this type the extraction of heat from the flame is not quite as complete as in the case where the flame travels lengthwise of the melting chamber. When the furnace is used for oil or gas, part of the fire box is bricked up and a checker-work of fire brick is placed on top of the brick filling.

In some cases a second melting chamber for melting ground coat glass has been built onto the cold end or side of the enamel melting chamber, the idea being to utilize for melting the ground coat glass some of the heat that ordinarily goes up the chimney. These have not proven very successful, mainly because the heat obtained is not sufficient to do much melting and supplementary

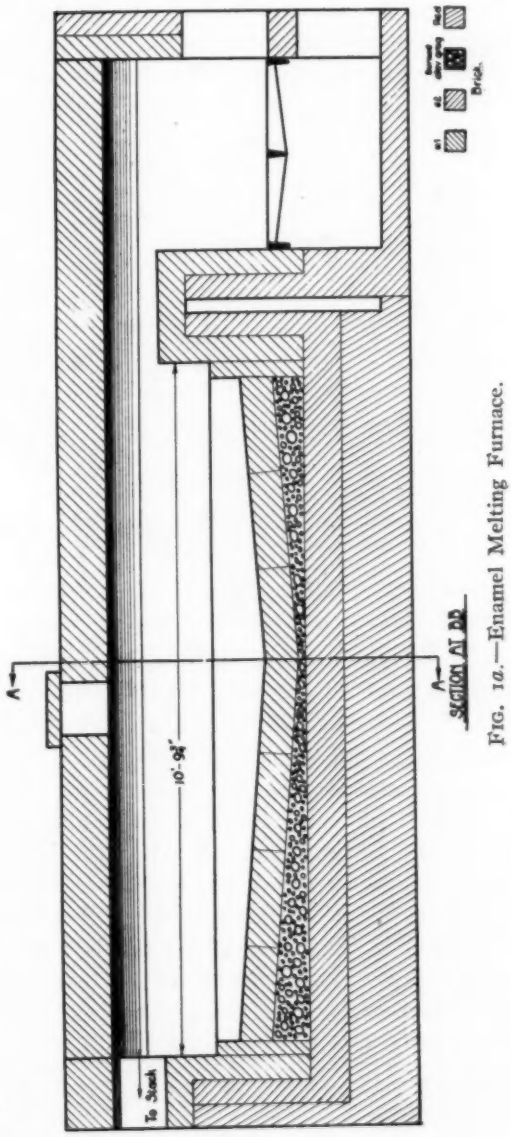


FIG. 1a.—Enamel Melting Furnace.

burners have to be installed. When the bridge-wall between the two melting chambers is not built hollow, the glass from one tank works through into the other. The melting tank for ground coat should be built like that for the cover coat but may be smaller. For ground coat glasses that are to be drawn while viscous, the

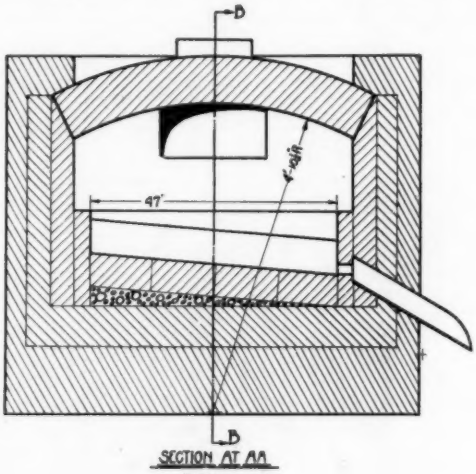


FIG. 1*b*.

tap-hole may be left about four inches square and stopped up by a couple of wedge brick. Sometimes ground coat glass is melted simply to a very viscous mass in scrap sinks, placed in the hottest part of an enameling furnace for 18 to 24 hours.

For melting enamels, natural gas, producer-gas, or oil should be used for fuel. With coal and coke, too much dust and ash is deposited on the melting enamel. Whatever kind of fuel is used, the flame should be thoroughly oxidizing, that is, a blue flame, free from smoke and incandescent carbon—which make a yellow flame. The least fuel is used when the draft is so regulated that the tip of the flame just reaches across the furnace. A shorter flame means that too much air is being used, and a longer one means that the stack instead of the enamel is being heated.

The Melting Process.—After the raw enamel batch is put into the melting tank, it is pushed back against the walls in every direction from the tap hole. This is done because the deepest

part of the melting tank is at the tap-hole, and if the top of the charge is made level it is difficult to melt the material deep down near the tap-hole. In the course of one to four hours, depending on the size of the batch, the melting is finished. The amount of stirring that should be done during the melting depends on the uniformity of the mixing of the raw batch, the type of furnace, and the kind of enamel. The finer the grains of the materials composing the batch and the more uniformly they are blended, the less the necessity for stirring. If a furnace of large capacity, compared to the size of the batch, is used, so that the material can be spread out in a thin layer, stirring is not so necessary Using thoroughly blended batches and large capacity furnaces, the author seldom found it necessary to stir tin enamels. In order to get uniform color in antimony enamels, stirring of the mix toward the end of the melting period must nearly always be practiced.

The objection to stirring enamels, aside from the small amount of labor involved, is contamination of the melt with iron from the stirring rods. It has been found that cheap tool steel rods give less scale than rod iron. The enamel adhering to the rods should never be broken off into the tank for holding good enamel. If the rods are chilled in a separate barrel of water, the dirty enamel may be saved and remelted with a new batch. In order to avoid stirring of the enamel, one company, making steel tanks, goes to the length of melting the enamel in what is virtually a large rocking ladle.

Tin enamels are nearly always tapped off within a few minutes after bubbling ceases. It was formerly held that this was necessary in order to prevent the enamel from overheating and becoming contaminated with metallic lead and tin. With better control over and understanding of our fires, we find that this reduction was not due to overheating but to reducing conditions in the flame and combustion gases used for melting. With a good clear blue flame, a tin enamel may be heated for hours after bubbling ceases without changing color. As explained in another section, the tint of antimony enamels varies greatly with the amount of heating they undergo. All enamels depending

in part on fluorides for opacity, especially fluorspar, become less opaque on continued heating.

3. Dryers.

The enamel is tapped out into a large tank into which a supply of cold water, amply sufficient to chill it, is running and is then taken to the dryers. One type of enamel dryer consists of a large revolving iron drum with a fire beneath it. A certain amount of fine iron scale is ground off this drum into each batch of enamel. In other cases the enamel is dried in thick layers in large pans heated by waste gases from a furnace or melting tank or by a separate fire. The enamel must be stirred in these in order to get it dried in a reasonable length of time and to prevent it from sticking to the pans, which become quite hot. In still another method the enamel is spread in thin layers in pans placed on racks in large drying cupboards. These are generally heated by gas. In this method no stirring is necessary and there is little contamination of the enamel, but the amount of room devoted to drying must be large. Rotary dryers, lined with porcelain blocks and having projecting shelves made by inserting rows of deeper porcelain blocks, have been built. These are heated by blowing hot air through them. They must be made quite large compared to their capacity, for if the blast of air traveling through them is strong, it blows out all the fine particles of enamel.

4. Grinding Machinery.

For grinding enamel, ball mills are used almost universally. Porcelain brick are nearly always used for lining. Formerly flint pebbles were used for grinding, but in late years the use of hard-burned porcelain balls has largely superseded them. Any particles ground off the balls show up less in the enamel than similar particles from the dark flint pebbles, and, when a good grade of porcelain is used, the balls wear less than the pebbles. While very hard and resistant to abrasion, the pebbles are brittle, and are often destroyed by splitting. The balls are worn down by abrasion a little more rapidly than the pebbles, but seldom split. Mills of from 250 pounds capacity per charge up to 3000 pounds are used. The size is largely a matter of choice, some of the largest plants using the smallest mills. Often large and small

mills are used in the same plant. Some enamel makers claim that with small mills there is less contamination of the enamel by abrasion of the linings and balls, but this is largely a matter of proper regulation of the charge and speed of the mill. Large mills require less labor for a given capacity.

In a few cases continuous ball mills, or tube mills, have been used. These have not proven very satisfactory, mainly because the output is small compared to the amount of power used and the money invested in the machines. The charge in a tube mill does not more than half fill the machine, while in ball mills, the charge usually fills the machine to 75 per cent of its capacity. Hence, the charge in the ball mills is more nearly balanced on the center of gravity of the machine and at the same time is larger—resulting in a greater output for a given amount of power and volume capacity of mills.

Whatever type or size is used, great care should be taken to see that no metal is exposed to abrasion. This is most likely to occur around the door frames. The resulting contamination of the glass causes black specks, which are especially noticeable in antimony enamels. Care should also be taken to prevent contamination of the enamel by grease and dirt from pulleys, belts and bearings. The wear on linings and balls will be lessened and the contamination from that source greatly reduced, if arrangements are made to empty the ball mills while they are running at a very slow speed.

Cover enamels are ground dry to a fineness such that they will pass a 60-mesh sieve. Ground coat enamels are usually ground wet to extreme fineness.

5. Screens.

In a few plants the enamel is not really screened in the mill room, being simply shoveled through a coarse riddle to take out lumps of enamel and small pieces of mill lining and stones. It has been found that the small amount of coarse material in the enamel powder seriously interferes with the speed of application of the enamel, and all enamel is screened in the mill room at most plants. The screen wire used is commonly about 10 meshes finer than that used in the dredges, *i. e.*, the sieves used in applying the enamel to castings.

Various types of screens are used, revolving screens probably being the most common. In order to get the enamel powder through these they must be jarred. Formerly, this was commmoly done by an iron hammer hitting on a ring of iron knobs encircling the center of the screen. With the introduction of antimony enamels, it was found that the contamination of the enamel by specks of metal from these knobs and the hammer was very noticeable. The use of rawhide hammers reduced the dirt somewhat and changed the specks from iron specks to carbon specks, produced by particles of rawhide. Various expedients have been employed to overcome this trouble with revolving screens, the most practicable of which seems to be the placing of the beater ring and hammer at one end of the screen frame, beyond the screening area. This eliminates the dirt but cuts down the capacity of the screen, since the jarring action is greatly reduced.

Another screen is of the reciprocating type. A flat screen is hung from a frame by wire cables and made to move back and forth by a short-stroke air motor such as is used for foundry riddles. Such a screen is clean and well suited to plants of moderate capacity. To keep down dust, it may be enclosed in a cabinet, the motor being placed on the outside. Of course, the air motor may be replaced by a belt-driven eccentric or any other mechanical device that will give a reciprocating motion.

A sifter adapted from the flour milling industry has a combined rotary and sliding movement. An oblong screen is set in a box with a solid bottom. One end of this box runs on rollers, while the other end, which is slightly higher, is supported by a ball and socket joint on the end of a pin set eccentrically on a horizontally running wheel. The sifter is operated by power applied to this wheel by an adjustable friction drive. As the pulley revolves, the upper end of the box takes a rotary motion while the lower end runs back and forth on the rollers. The horizontal pulley, and of course the upper end of the box, make about two hundred and thirty revolutions a minute. The enamel passing through the screen slides down the inclined bottom of the box and out through a chute at the lower end. The coarse material passes out through a similar chute at the lower end of the screen. Since

all wearing surfaces in this machine are below the floor of the box in which the enamel is sifted and caught, there is no contamination of the enamel powder from that source. The capacity of this screen, as well as of the sliding screen previously described, may be materially increased by attaching to the screen frame a compressed air vibrator, such as is used for vibrating molds in foundries.

THE ENAMELING PROCESS.

1. Application of the Ground Coat.

After being sand-blasted and cleaned, the castings should be kept in a dry, warm place until ground-coated, which should be done within a few hours. The ground coat can be applied by painting, pouring, or spraying. In painting, a ground coat composition of about the consistency of thick gravy is spread over the surfaces to be enameled by means of flat painter's brushes—four-inch brushes are used for tubs and two-inch for small ware. The brush marks are likely to show through the enamel, especially if the piece is heated strongly during the firing of the ground coat or enamel. The heat causes incipient blistering and swelling of the heavier ridges left by the brush. For this reason, painting of ground coats is not extensively practiced. Sometimes when certain parts of a piece are to have an especially thick coat, these are painted before the piece is poured or sprayed.

In pouring, enamel of about the consistency of cream is poured over the casting. If the piece is small, it is turned in various positions and rocked backward and forward on two rods extending over a drip tub until the ground coat is smoothly on the surface of the whole piece. The thicker beads, that accumulate at the edges, are removed by running a finger along them. In the case of tubs and other large pieces, the ground coat is poured on as uniformly as possible, then the piece is placed in various positions and pounded with a rawhide mallet. The vibration tends to cause the coat to run smooth. When done by a skilled man, working with ground coat enamel of proper consistency, coatings of very fair uniformity can be produced by pouring. It is a more rapid method than painting but not as rapid as spraying.

It is by spraying that the most uniform coats are applied, and at the same time with the greatest speed. The spraying devices are operated by compressed air, various types being sold for the purpose. In addition, a number of kinds of home-made sprayers are used in different plants. In general, it has been found that sprayers which depend on suction for their supply of coating give finer-grained and more uniform sprays than those depending on pressure. The sprays should be as fine grained as is consistent with reasonable speed of operation. The ware is usually placed on a turn-table while being sprayed. In some shops, small ware is sprayed on a regular small-ware enameling table.

In spraying, only one-third to two-thirds of the material coming from the spray nozzle lights on the ware. Therefore, the spraying space should have a smooth wooden floor and smooth wooden walls on three sides. If the castings are clean all over before they go to the spraying cabinet and the workmen do not carry in dirt on their feet, the ground coat on the floor and adhering to the walls may be gathered up, sieved and used over again. Dust from cement or brick walls and floors is liable to contaminate the ground coat.

If an exhaust fan is used to carry away the vapors from the spray chamber, a large box or collection bin should be placed in the pipe line. This will act like a dust collector and most of the material carried away will be deposited. It is best not to try to use this for ground coat alone but to mix it in small proportions with fresh coat.

The following simple device for conserving labor and material in the spraying of tubs is in use in several plants: The tub is run on a truck into a three-sided wooden stall having a runway around the top of the sides, which extend a few inches above the rim of the tub. The operator walks around the tub on this runway, spraying as he goes. The waste material is caught by the sides of the stall and may be used again.

After being ground-coated, the ware must be kept in a dry warm place until enameled in order to avoid incipient rusting of the iron. This time should be brief, twenty-four hours at the most. Usually the pieces are stored near the enameling furnaces.

2. Enameling Room Equipment.

The enameling room is usually rectangular in shape with furnaces along one side. This room should be well lighted and ventilated and have a high roof, the lowest girders being at least twenty feet from the floor. A high roof not only makes a better ventilated room, but reduces the amount of enamel powder and dust that lights on the girders and drops or is blown down from time to time. Latticed monitors and in fact any kind of ventilators that can retain dust are also objectionable. The overhead girders and underside of the roof should never be white washed, as the coating peels off and spoils any hot enameled surface onto which it drops. When furnaces are built on both sides of the room it is likely to be dark and is always very hot.

The furnaces used for enameling cast iron are large rectangular ovens having an arched roof and a wide door at one end. If coal is used for fuel, the sides and arch are built double, forming a tight muffle. If gas is used, the inner arch is sometimes omitted, thus making a semi-muffle. For tubs, the inside dimensions of the muffles are about nine feet long, six feet wide, and five feet high to the crown of the arch. Small ware furnaces are made about six feet square by four feet high, inside dimensions.

Various types of furnaces are used, most of the variations being made in the flue systems. Very elaborate flue systems have been embodied in furnace construction with the idea that the longer the length of travel of the flue gases in the furnaces the greater the amount of heat given up. This, of course, is not necessarily true. These elongated flues are generally placed in the roof and sides of the furnace, which receive large amounts of heat by radiation and conduction from the muffle and heating flues proper, and it happens often that the combustion gases leave the flues at a temperature fully as high as that at which they entered. In other words, heat cannot be withdrawn from gases by leading them through heated flues. In other cases, these flues are placed farther away from the hot parts of the kiln and nearer the outside surfaces. The gases then leave the flues at temperatures somewhat lower than the entering temperatures. However, the heat given up simply goes to heat portions of the kiln exterior that are normally cool and to increase the radiation from these. The

only way possible to extract heat in useful form from hot flue gases is to use the hot gases for heating the air used for combustion—by means of some form of regenerator or recuperator.

In general, it may be said that the simple types of furnaces give the greatest satisfaction. Complicated flue systems are prone to result in poor draft and frequent stoppage of flues with soot. The more complicated the construction of a kiln, the greater is the possibility of its going to pieces under the strains incident to expansion and contraction of the furnace on heating and cooling. Complicated furnaces are expensive to build, difficult to operate, and expensive to keep in repair.

In Fig. 2 is given the plan for a tub furnace that has been used with good results in several plants. Part of the flame from each burner goes directly up along the wall and over the top to the central collecting flue. The main portion passes under the floor, up the opposite side, and over the top to the same collecting flue. The distribution of the flame is controlled by the dampers. By using a short flame, most of the heat is generated under the bottom and in the lower ends of the side flues and the products of combustion enter the collection flue at a comparatively low temperature. The material for this furnace can be had at reasonable prices since the construction calls for no special shapes, except the cup brick for the muffle, and these are used in large quantities by the enameling and other industries. As shown, the furnace is intended for the use of natural gas, producer-gas, or oil. The burners are placed alternately on the sides of the furnace. When used for coal, fire boxes are added at one side, each fire box serving two flues, and all the firing is done from the one side. By removing the top arch of the muffle, this furnace can be readily converted into an open arch, or, in other words, a semi-muffle furnace.

In a few plants, double-chamber furnaces of this type are used, the firing being all done on one side. One part of the products of combustion passes under the floor of both chambers and up the far wall of the second. The other part passes entirely over the top of the first chamber, through the division wall near the floor level, and up the inner side of the second chamber. The first chamber is always a tight muffle, but the second is usually

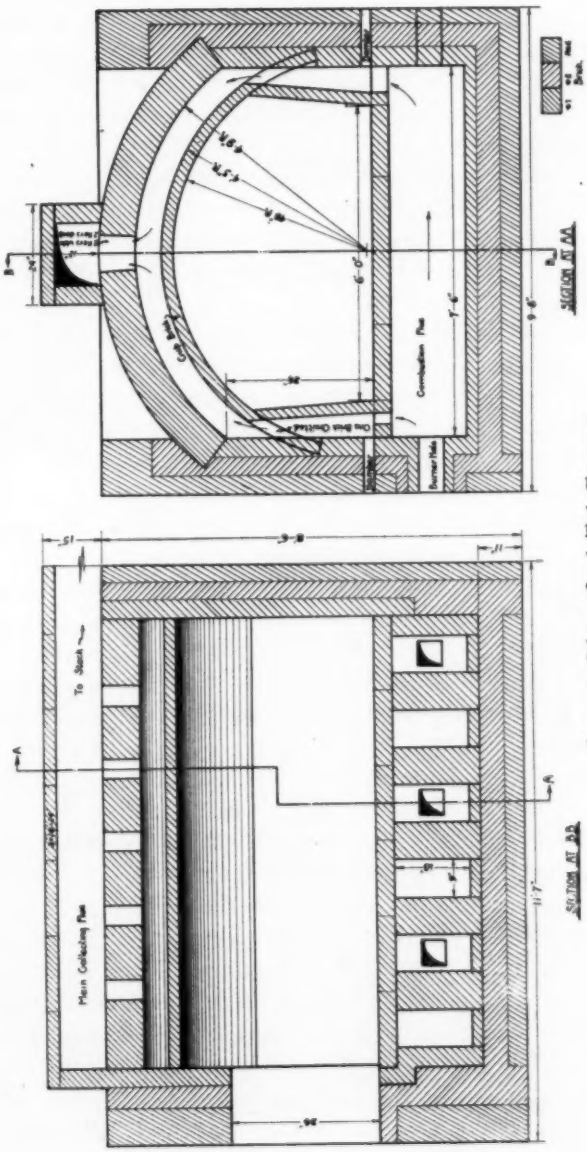


FIG. 2.—Direct-fired Tub Furnace.

operated as a semi-muffle furnace. The final melting of the ground coat and all baking of enamels is conducted in the first chamber, which is kept at ordinary enameling furnace temperatures. The second chamber, which usually is at a dull red heat, is employed for preheating the tubs, covered with ground coat, to dull redness.

From a double furnace, more pieces can be turned out in a given time with less expenditure of fuel per piece than from a single furnace. However, since the double furnaces save nothing in labor, this rapid rate of working is very severe on the workmen and often causes dissatisfaction.

Another type of furnace which has come into use in a few plants burning gas or oil has no fire boxes. Flames are turned directly into the furnace chamber so as to heat it to a temperature suitable for enameling. The supply of fuel is then shut off and the tub is enameled simply by the radiant heat of the hot furnace walls. As soon as the tub is removed from the furnace, the flames are turned on again. This type of furnace is cheaply constructed and very economical in the use of fuel.

In Europe, where fuel is very expensive, a number of types of enameling furnaces equipped with recuperators have been built. A few such furnaces have been constructed in this country, after European designs. In Fig. 3[1] is shown the plans of a European furnace with a recuperator built integral with it. It will be noticed that the large fire box is, when covered with a very thick bed of fuel, really a gas-producer. This feature is one of the chief advantages of such furnaces. The air for combustion of the gases produced travels around the tubes of the recuperator and is preheated by the out-going combustion gases. According to Damour,[2] recuperation of secondary air for furnaces with a working temperature of 1800° F. will give a fuel economy of 30 per cent. These furnaces give good satisfaction, but it is a question how much of this efficiency is due to the recuperative feature and how much to the gas-producer and heavy, heat-retaining construction in general. The first cost of these furnaces is quite

[1] E. A. Schott, *Stahl u. Eisen*, **30**, 1556.

[2] Emilio Damour, "Industrial Furnaces," p. 127. (Published by *Engineering and Mining Journal.*)

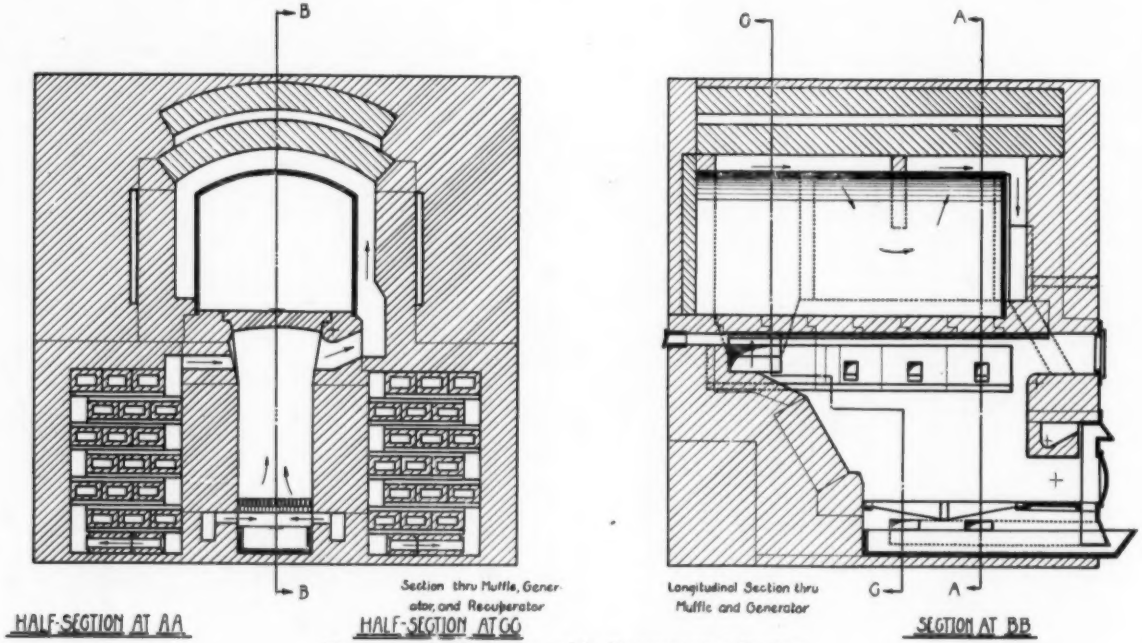


FIG. 3.—Muffle Oven with Recuperator System.

high—usually about double the cost of a simple direct-fired furnace.

The fuel consumption of any of the foregoing furnaces can be materially decreased by covering them with a layer of some of the heat insulating materials now on the market. In regard to irons and braces, it may be said that the more substantial these are the less the cost for repairs to the furnace. In regard to the use of open arches versus tight muffles—it is to be considered that where open arches call for much less fuel than closed arches, their use is more likely to give ware of poor finish and contaminated with dirt from the roof of the furnace.

The doors to the furnace may swing sidewise, rise up, or drop down. Swinging doors, whether single or double, suck out hot air when opened and push in cold air when closed. Lift doors are liable to cause dirt to be dropped onto a piece of ware being taken out of, or put into, the furnace. Dropping doors are the cleanest and do not cause air currents. The only disadvantage is that it is not possible for the enameler to open them a little way in order to observe a piece of ware in the furnace. Of course, opening a door to look at ware is merely a matter of habit and convenience, for the piece can always be inspected through a peep-hole left in the door. Rising doors are most commonly used. In most plants, compressed air is used for operating tub-furnace doors—a simple hoist with a wire cable running over sheaves being the common apparatus. In some plants electricity is employed. Occasionally, power is used to open small-ware furnace doors, but the more common practice is to have them opened by hand. Power-operated rising and dropping doors are counter poised so that they are self-opening, the power being used simply for closing and keeping them closed. This greatly reduces the mechanical problem of operating the doors and at the same time gives assurance that the furnace will be open for the extraction of ware if anything goes wrong with the power.

Supporting the Ware.—The ware, while being enameled, is placed on a rack or table, known as an enameling table. This table is fitted with gears and levers which permit the top being tilted at any angle to the perpendicular, or even turned upside down in some types, and revolved while in the various positions.

Any good master-mechanic can design such a table and consequently there are many varieties being used, most of them being indigenous to the shops in which they are found. In general, the tables are tilted on the main horizontal axle of the frame and revolved around a pin extending through this axle. In tables not intended to have the top turned completely over, the center of rotation is placed between the two bearings of the main axle. In tables whose tops are to be completely reversed, the center of rotation is placed on an end of the main axle entending beyond both bearings. Similar tables are used for enameling small ware but in most cases these are operated by hand.

Formerly a hand crank was used for rotating enameling table tops, but in the more modern plants the tops are rotated by power. One type of table uses a reciprocating air motor, which produces a rotary movement by means of a series of cams articulating with gears. Such tables are jerky in their action. A much more satisfactory method is the gearing of a rotary air-motor or small electric motor to the mechanism ordinarily used for rotating the table top by hand. The top should rotate at a speed of ten to twenty revolutions per minute. With an air motor the speed can be largely regulated simply by the amount of opening of the foot-valve used. The tilting is still commonly done by hand, but in a few shops this is done by the use of a small air hoist and suitable sheaves and pulleys.

For supporting the ware in the furnaces while being heated, various sorts of racks, called "bucks," are used. These are generally made of heavy sections of cast iron. Sometimes old railroad rails are used for bucks for tubs and, less frequently, blocks of fire clay. The latter do not warp nor deteriorate by oxidation like metal but are difficult to shift about into proper positions in hot furnaces. The best form of buck for tall cylindrical pieces, such as lavatory pedestals and drinking fountains, is a heavy base with an extension curved so that a long finger points horizontally toward the door of the furnace. The pieces are fired on this finger and, being in the horizontal position, are heated much more uniformly than when fired in an upright position.

The ware is put into and taken out of the furnaces by long

two-pronged forks, which are suspended either from a crane or from a trolley running on an I-beam. Sometimes dirt drops off the I-beam into ware, but the trolley system is steadier and easier to handle than the cranes. In a few plants the forks are pivoted on a truck running on tracks extending out from the front of the furnaces. This is a clean system, but does not permit of ready adjustment of the fulcrum point of the fork to ware of different heights.

Application of the Enamel.—Enamel powder is kept more free from dust and is more readily obtained by the operators working at high speed while enameling, if it is kept in a covered receptacle from which it can be made to feed semi-automatically in fixed quantities into the enameling sieves or dredges. Such contrivances are generally known in the shops as "powder dummies." One form of dummy consists of a large funnel with a drum at the bottom divided into six wedge-shaped compartments. The drum rotates on its horizontal axis and, except at the bottom and top, is entirely encased by close fitting walls. Whenever the contrivance is not being operated, one of these compartments forms the lower end of the large funnel. When he needs enamel powder, the operator pushes with his sieve on a rod reaching below the drum, the movement of this rod operating a pawl which causes the drum to rotate one-sixth of its circumference. In this way one of the compartments is emptied into the sieve.

A much more simple form of dummy consists of a large circular funnel with a tubular extension on the bottom. This extension is closed by a swinging slide with a weighted projection at the bottom. To operate this dummy, the enameler pushes with his dredge on the weighted projection. The slide is thus pushed back and the sieve brought into position under the tube, the enamel in the tube immediately dropping into the dredge. When the pressure is removed, the weight on the projection causes the slide to close. The enamel in the funnel proper slowly drops down to fill the tube again. This simple contrivance is much less likely to get out of order and costs less for repairs than any of the more complicated dummies.

For protecting tubs from drafts during cooling, covered stalls, called "dog houses," just large enough to hold one tub on a truck, are provided. The front of these stalls may be open or may be provided with loose fitting doors. Tight doors do not allow a tub to cool fast enough and thus favor the growth of minute crystals on the surface of the ware, which cause dull finish. These stalls may be built of any solid material. Sheet iron is not suitable, especially for the roof. The light sections of metal buckle with heat from a hot tub and throw dirt onto the still soft enamel. It is not customary to use cooling chambers for small ware.

The dredges used for sifting the enamel onto the ware consist of circular sieves attached to handles about five feet long. In order to have the enamel pass through the screen in an even stream, the sieves must be vibrated. In a few shops this is still done by rapping the wooden handle of a dredge with a beater. The beater consists of a small oval hoop of about $^3/_8''$ round iron having a wooden handle fastened to one end. The oval is placed around the handle of the dredge and worked rapidly up and down by the right hand of the enameler while the dredge is held by his left hand, and, in the case of large sieves, partially supported by a counterpoise. The more common method of vibrating dredges is by means of a small air or electric vibrator attached to the end of a gas-pipe handle on the dredge. The common form of air vibrator is a small chipping hammer with a blunt point substituted for the chisel. This may be a long rod with its tapping end beating against a plate attached to the wall of the sieve, or it may be very short and beat against a hardened disk held in a case at the end of the dredge handle. Since the whole dredge, including the handle, must be vibrated in either case, the point of application of the blows is obviously immaterial. Electrically operated vibrators of several types have been used, but they have not proven as satisfactory as the air hammers. The introduction of mechanical vibrators for enamel dredges has been a great boon to the enameling industry. They enable the workmen to produce more and better ware with much less effort. Formerly, paralysis of the hand used for beating was not uncommon among enamelers. For hand vibrated

dredges, 30 to 40 mesh-wire gauze is used, while for power-vibrated, 40 to 60-mesh is employed.

3. Enameling a Bath Tub.

Having previously been coated with ground coat, which must be perfectly dry, the tub is caught up along the under side of the rim by one of the large forks, operated by the two enamelers, and placed in the furnace. In from seven to ten minutes, the iron is a bright, cherry-red, and the ground coat has melted evenly. The piece is quickly withdrawn and placed on the revolving table. One man sifts enamel on the rim through a small sieve while the other man dredges the sides and bottom. The heat of the iron fuses the enamel enough to make it stick to the surface. In about three minutes the piece is thoroughly covered, and is immediately put back into the furnace. In a few minutes the enamel has melted smooth, and the tub is drawn and given another coat. This runs smooth in a few minutes, and the piece is again drawn. Any blisters appearing are patched by being perforated by a steel point and covered with a little mound of enamel powder. The tub is given a third light coat and allowed to bake. It is then drawn, any enamel that has run over the edge of the casting is trimmed off with a large knife, and the piece is allowed to cool in a "dog house."

The proper enameling of a tub is a matter of considerable skill and judgment. Each dredge must be evenly distributed over the piece. If it is too thin in places, blue spots show on the finished ware; if too thick, crazing or chipping off of the enamel may occur. One fault especially difficult to avoid is the tendency of the enamel to run and collect in rolls or beads at certain points. This spoils the appearance of the piece and often results in crazing when the tub cools.

The temperature at which practically all tub enamels mature is very close to 1000° C (1800° F.). It may not be much higher, for between 1050° and 1100° C (1900 and 2000° F.), cast iron burns "dead," becoming exceedingly weak and brittle. It cannot be much lower on account of the increased cost. An enamel that would mature much earlier would have to be considerably higher in the more expensive fluxes. Another important con-

sideration is that an enamel which would mature much earlier would be a softer glass, more readily soluble, and more liable to deteriorate under the ordinary conditions of use. An enamel for cast iron that will meet all the requirements of the service for which it is intended can be made at 1800° F.

Though the enamel matures at 1800° F, the furnace is fired to a considerably higher temperature. The temperature is kept down by the process of enameling. Every thirty minutes, or thereabouts, a cold tub weighing from 200 to 300 pounds is put in, heated to 1800°, drawn out three times, allowed to cool considerably and heated up again after each cooling. This process keeps the furnace and the men busy, insuring a maximum output of ware, but it calls for skill and watchfulness on the part of the enameler. Each coat of enamel is baked very quickly; it is melted down in from two to five minutes in a rapidly rising heat. Exposure for a minute too long in the furnace during any one of the four heating periods may ruin the piece. The defect may be burning up of the slush coat, sulphur bubbles, running off of the enamel, etc. If the tub is not heated sufficiently, the result will be pin holes in the coldest parts, and a rough, uneven coat, of poor luster.

After the tub is cold, it is carefully inspected as to defects in application and fit of the enamel, color, luster, etc. Minute crazes are readily detected by rubbing the surface with a rag filled with black grease. The tub is then painted on the outside, supplied with feet and fittings, and taken to the ware room.

A PYCNOMETER OPERATED AS A VOLUMETER.[1]

By H. G. Schurecht, Columbus, Ohio.

Owing to the fact that in studying the drying and burning behavior of clays, the volume shrinkage can be determined more accurately than the linear shrinkage,[2] a satisfactory volumeter for measuring this shrinkage is an important piece of apparatus in a ceramic laboratory. Heretofore, the Seger volumeter,[3] although unsatisfactory, has been used almost universally. Some of the objections to the Seger volumeter are enumerated as follows:

1. It is too time consuming. In order to obtain accurate results with a Seger volumeter, it is necessary to allow the liquid in the burette to drain at least 3 minutes before making a reading. The total time required for a single determination of volume varies from 5 to 10 minutes.

2. Particles of grit or clay may become lodged in the large stopper joint—thus changing the volume of the bottle when closed.

3. It is quite fragile and easily broken.

4. Errors are often introduced through the entrapping of air bubbles.

Pycnometer Volumeter.—In order to overcome some of these objections a volumeter (Fig. 1) operating on the principle of the pycnometer was used in the Bureau of Mines Laboratories with excellent results. The bottle is made of glass—metal being considered too heavy as it would decrease the sensitiveness of the balance and thereby decrease the accuracy of the determination.

[1] By permission of the Director, U. S. Bureau of Mines.

[2] J. Bailey, "Variation in Linear Shrinkage of Clay Test Pieces," *Trans. Am. Ceram. Soc.*, 18, 557–563 (1916).

[3] For details regarding operation of the Seger volumeter see H. Ries, "Clays, their Occurrence, Properties and Uses," Robert Drummond & Co., N. Y., pp. 160–62.

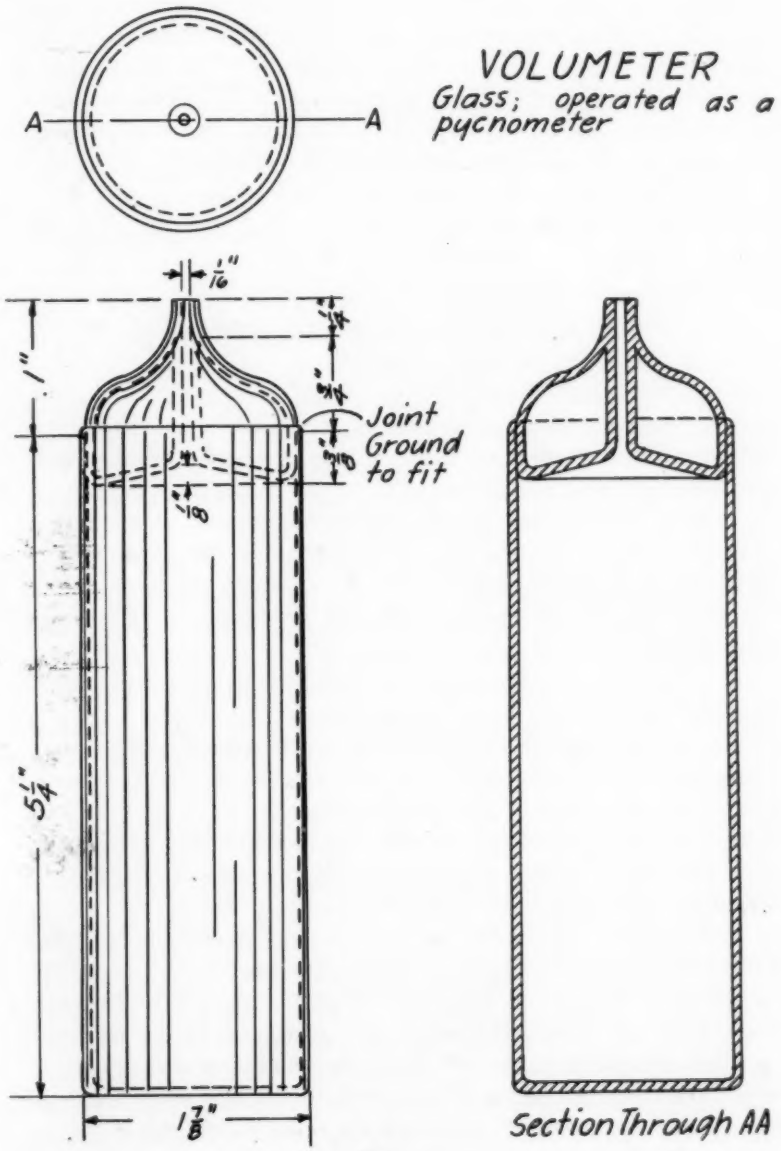

VOLUMETER
Glass; operated as a pycnometer
A
A
1/16"
1"
Joint Ground to fit
1/8"
5 1/4"
1 7/8"
Section Through AA

FIG. 1.

Operation.—The bottle is filled with liquid (kerosene or water) and, as the stopper is inserted, sufficient liquid is forced into the tube in the stopper so as to fill it completely. The excess liquid is carefully wiped off and the bottle is weighed. The briquette to be measured is then inserted into the bottle and the operation is repeated. The calculation involved is as follows:

$$V = \frac{W - W_1 + B}{S}$$

V = Volume
W = Weight of bottle plus liquid
W_1 = Weight of bottle plus liquid plus briquette
B = Weight of saturated briquette
S = Specific gravity of liquid

It is necessary to check the weight of the bottle plus the liquid at intervals as minute particles of clay, dropping from the briquettes, may increase this weight.

A mark is scratched on one side of the stopper and bottle so that the stopper may be placed each time in the same position with reference to the bottle—any error which might be caused by inserting the stopper in different positions being thereby eliminated.

In comparing this type of volumeter with the Seger volumeter it might be said:

1. That it is much more rapid, in that a determination can be made in from 1 to 2 minutes as compared with the 5 to 10 minutes required when using the Seger volumeter.

2. It is very accurate. Volumes can be determined to within 0.01 to 0.05 cc.—the accuracy depending on the size of the briquette and the sensitiveness of the balance used.

3. The error due to the lodging of grit or clay in the joint of the stopper and to forcing the stopper further down into the bottle in one case than in another would be less in this apparatus than with the Seger volumeter—as the stopper of the former is smaller and the displacement would be smaller in proportion.

4. There is less chance of error from air bubbles.

5. It is not as easily broken as the Seger volumeter.

6. It is less expensive.

COMMUNICATED DISCUSSION

By F. Gelstharp.

OF THE PAPER

"THE EFFECT OF CERTAIN IMPURITIES IN CAUSING MILKINESS IN OPTICAL GLASS."

By C. N. Fenner and J. B. Ferguson.[1]

The Pittsburgh Plate Glass Company has been very successful in producing the several types of optical glass. Although in our early work we occasionally encountered milky or opalescent glass, either in the pot or after molding, we have not observed the phenomenon for a long while. The only glasses in which this opalescence was produced were the borosilicate crown (refractive index 1.522) and dense flint (refractive index 1.616). Impure potassium carbonate was not the cause of the opalescence because the pure nitrate was used in place of carbonate. I do not feel that the authors of this paper have positively proven that the presence of sulphates in certain optical glasses will produce opacity or milkiness.

This is a very interesting subject to glass manufacturers generally as opalescence has been the cause of trouble in other branches of the glass industry. When ordinary soda-lime glasses turn milky or slightly opalescent, the milkiness may invariably be eliminated by a slight increase in the alkali content of the glass.

From the small amount of research work I have done on simple glasses, I believe that I am correct in stating that, having a supersaturated solution of silica, the tendency is for this to precipitate out, either on cooling slowly, or, if the cooling is too rapid, it will separate on reheating. I therefore propose a different view for the solution of this problem.

The optical glass referred to by the authors and those glasses which I have mentioned contain a very high molecular content of silica and therefore approach supersaturated solutions. If for some reason the alkali content is lower than intended, milk-

[1] *J. Am. Ceram. Soc.*, 1, 468–476 (1918).

iness may easily result. I would offer the following explanations for this:

First: In the case of Russian potash, if a batch were made up containing 68 parts by weight of potash (calculated to anhydrous K_2CO_3 assuming that the KCl and K_2SO_4 present will supply their quota of K_2O) to 300 parts of sand, it is very probable that there would be a deficiency in alkali sufficient to produce a supersaturated solution. In case melts from this batch did not opalesce, probably a higher temperature prevailed and the K_2SO_4 dissociated or reacted with the silica in solution, yielding its quota of K_2O, this reaction being more or less complete. Some of the KCl may have reacted and supplied some K_2O, part may have remained in solution as KCl, and the remainder may have been volatilized.

Second: Bearing in mind the first probability, there was evidently considerable variation in the composition of the Russian potash which might account for some of the melts showing opacity.

Third: We have found that a considerable amount of alkali may be lost by volatilization and that the amount varies with furnace conditions. This might also account for the erratic results secured when the proportions are so near a supersaturated solution.

A case is cited by the authors in which melts were made in two pots in the same furnace, one producing milky and the other clear glass. The respective content of SO_3 is stated to have been 0.10 per cent and 0.05 per cent, respectively—the Cl content being the same in each melt. It is remarkable if such a slight difference could possibly account for the conditions of opalescence —I feel that some other reason must be found to adequately explain it.

I feel convinced that, in the case of the borosilicate crown and dense flint glasses to which I referred, the milkiness was due to a deficiency of alkali—due to volatilization caused by improper melting conditions. I suspected that the arsenic was responsible for the cloudiness but subsequent melts in which a larger amount was used in the batch did not develop it. In one of our early experiments an excessive amount of arsenic was introduced by mistake and a dense white glass resulted. This

was also probably due to the formation of a supersaturated solution of silica on account of the fixation of a portion of the alkali by arsenic.

I have never found that the presence of SO_3, Cl or F in soda-lime glass (in amounts up to 0.6 per cent of each) caused opalescence to the slightest extent, so long as the ratio of alkali to silica was below the limit at which opalescence occurs when SO_3, Cl or F are absent.

In the case of opal glasses, such as the so-called Carrara glass, fluorine is generally used in some form, but its efficiency in producing opacity seems to depend on both the form in which it is introduced and the ratio of alkali and other bases to the silica. It has never to my knowledge been positively proven whether the opacity in this case is due to separated silica or to some fluorine compound.

I do not wish to convey the impression that the authors are incorrect in concluding that the presence of SO_3 and Cl in some optical glasses will cause milkiness, but simply to suggest that before this can be accepted, further experimentation is necessary. However, I believe it is very probable that the presence of salts in solution in glasses which contain a high proportion of silica (approaching a supersaturated solution) will tend to cause such glasses to more readily turn milky on slow heating or cooling.

PITTSBURGH PLATE GLASS COMPANY,
CREIGHTON, PA.

REPLY TO F. GELSTHARP'S DISCUSSION,

BY C. N. FENNER AND J. B. FERGUSON.

We are very glad that Mr. Gelstharp has brought up for consideration the possibility that the opalescence or milkiness which we have described was caused by a deficiency of alkali. This is a reasonable hypothesis and deserves careful consideration, but the evidence does not seem to us to support it. We wish, however, to emphasize again the statement which we made in the original article, that we do not intend the explanation there offered to be understood to apply to all cases of milkiness or devitrification in glasses. It is only reasonable to suppose that a deficiency of alkali in a glass would be a contributory cause, and under some circumstances might be the most important

cause leading to devitrification. Nevertheless, we are strongly of the opinion that many glasses are somewhat supersaturated with silica and still do not ordinarily turn milky or devitrify, but that other factors may come in which exert controlling influences and lead to this result.

In what follows we wish to restrict ourselves to the phenomena which we discussed, and to give reasons why Mr. Gelstharp's interpretation does not seem to apply.

1. A suggestion is made as to the manner in which the use of a potash carrying SO_3 and Cl might lead to a deficiency in alkali. This is based upon a perhaps natural assumption as to the manner in which we allowed for the presence of these ingredients in our calculations, but as a matter of fact the procedure that we followed had a tendency to increase rather than decrease the percentage of alkali.

As we have mentioned, the maximum SO_3 content of Armour potash which it was considered judicious to tolerate for the light flint glass was 0.30 per cent, and with even this amount there was found to be a tendency toward the production of milkiness. That this was not due to a deficiency in alkali is shown by a consideration of the method used in adjusting our calculations. This was as follows: Since there is no reason to suppose that the K_2O content of K_2SO_4 in a lead-alkali-silica mixture is more volatile than the K_2O of K_2CO_3, its equivalent in terms of K_2CO_3 was calculated and used as such if the K_2SO_4 content was large, but if it was only 0.20–0.30 per cent (as was generally the case) it was believed that no essential difference in the glass would be made by reckoning the K_2SO_4 as K_2CO_3 without conversion. The effect of this, as regards the composition of the glass, was almost imperceptible, as the following calculation shows:

Suppose the raw potash contains 80 per cent anhydrous K_2CO_3 and 1 per cent K_2SO_4 (equivalent to 0.46 per cent SO_3).

If all the K_2SO_4 were called K_2CO_3, this would make 81 per cent K_2CO_3 in the raw potash, and to get 68 kg. of anhydrous K_2CO_3 in the batch 83.95 kg. of raw potash would be used. This would be supposed to contain 46.376 kg. of K_2O. Taking account of the K_2SO_4, however, the 83.95 kg. of raw potash would actually contain 45.803 kg. of K_2O from carbonate and 0.454

kg. of K_2O from sulphate, or a total of 46.257 kg. of K_2O instead of 46.376 kg.

A batch of the kind under consideration would yield about 590 kg. of glass. The percentage of K_2O in the glass in the two cases would be

(*a*) 46.257 ÷ 590 = 7.84 per cent.
(*b*) 46.376 ÷ 590 = 7.86 per cent.

That is, the error (deficiency) arising from considering the K_2SO_4 as K_2CO_3 would amount to 0.02 per cent K_2O in the final glass, an insignificant amount.

KCl was treated differently. Data on what happens to KCl in a batch of this kind are very meager, but as we know that KCl is highly volatile, and as the amount was small, it seemed safest to consider that *all* of it escaped and not consider it a source of K_2O at all. Possibly some objection might be raised to this procedure but the reason for it would be the converse of that which Mr. Gelstharp has suggested. If any of the KCl did become converted into a K_2O compound and remain in the melt, the effect was to *raise* the K_2O content.

2. Mr. Gelstharp speaks of the probability that the glasses approach a supersaturated solution, and there seems to be an implication here that, as regards composition, they are in a critical region and that a little addition of silica will throw them over into a condition of supersaturation, causing a precipitate of silica to appear. We hesitate to believe that such is the state of affairs. We are rather inclined to think that all glasses of the type under discussion are somewhat supersaturated at 950–1000° C[1] and that a few tenths per cent increase or decrease in silica has no effect. A certain set of laboratory experiments which we have lately carried out gives evidence on this and other points.

A glass which became milky on reheating was used as the basis for the experiments.

Experiment 1. Several chunks of glass were placed in a platinum crucible and heated for about an hour at 950–1000° C. The

[1] Necessarily a definite temperature must be expressed; otherwise supersaturation has no meaning. We have taken a temperature at which latent milkiness is developed on reheating.

3. Although laboratory experiments of this kind tend to support our conclusions, we do not attach nearly so much importance to them as to the large-scale experiments which the commercial operations represent. These showed the striking fact that when proper measures were taken to maintain the furnace temperatures at the desired level, the appearance of pots of milky glass ceased immediately, and for months following, trouble of this kind was practically negligible.

It is difficult to understand how this procedure can be supposed to cause more of the somewhat volatile alkalies to be retained in the melts, but it is easy to see that it would tend to drive out the last traces of any such materials as SO_3 or Cl.

Before making the changes in methods of temperature-control which we have described, Mr. Victor Martin, then chief glass-maker at the Bausch and Lomb plant and a man of wide experience in practical glass-making, had expressed the opinion that the trouble arising from milkiness could be obviated if it were possible to operate the furnaces at a higher temperature. Later experience showed that this was essentially true but that it was only necessary to keep the temperature at a point very little above that which we had believed to be suitable for ordinary conditions but which at times was not attained because of deceptive thermoelement indications.

Mr. Gelstharp refers to certain observations of his on the effect of arsenic in producing milkiness. He believes that the arsenic fixes a certain amount of alkali and thereby increases the amount of uncombined silica. Even if this be true, the amount of alkali which can reasonably be supposed to combine with the small amount of arsenic which is sufficient to produce milkiness is so small as to be practically negligible. To us it seems at least as reasonable that the action of arsenic is similar to that which we have assigned to SO_3 and Cl.

A criticism which seems to us applicable to Mr. Gelstharp's point of view is that in drawing his conclusions he does not make sufficient distinction between the amount of SO_3, Cl and As which is put into the melt and that which stays in. All of these materials, in whatever form they are added, tend to be volatilized at high temperatures, and the statement that in certain cases

a relatively large amount of one or the other went into the melt without producing milky glass has, of itself, little bearing upon the question. We need to have in addition fairly complete information on the subsequent heat treatment or an analysis of the glass.

Although we agree with Mr. Gelstharp that final proof of our contention has not been obtained, nevertheless the evidence in that direction appears to us very strong, and no other explanation appears to meet the requirements.

GEOPHYSICAL LABORATORY,
CARNEGIE INSTITUTION OF WASHINGTON,
WASHINGTON, D. C.

HEAT BALANCE ON A PRODUCER-GAS FIRED CHAMBER KILN.

By R. K. Hursh, Urbana, Ill.

The data presented here are based on tests made at the plant of the Baker Clay Company at Grand Ledge, Michigan, in the summer of 1917. The equipment tested consisted of a kiln of sixteen chambers, each having a capacity of fifty to fifty-five thousand standard sized brick, and three six-foot, water-sealed gas-producers of the pressure type.

The producers were connected by a header with the main gas-duct leading to the kiln. Each producer was equipped with a blower of the injector type using steam at pressures ranging from fifteen to forty pounds (gauge). A Virginia lump coal in sizes up to four inches was fired in charges of one hundred and fifty to two hundred pounds to each producer at hourly intervals.

Air for combustion in the kiln was drawn through the open doors and crown holes several chambers back of the one on fire and the combustion gases were passed through three heating chambers before delivery to the stack flue. No use was made of the usual water-smoking flues on the top of the kiln. The average firing period was forty to forty-four hours, the finishing temperature being 1075° C (1970° F.) in the top of the chamber.

Tests.

Coal was weighed separately for each producer and an average sample was reserved for analysis. Ashes were removed from the pits every other day and a sample was taken for analysis. Both analyses were made by J. M. Lindgren at the Chemistry Dept. of the University of Illinois.

The steam pressure at the blowers of the producers were taken at hourly intervals and the diameter of the orifice in the blower was measured. From the average pressure and the area of the orifice, the steam consumption was calculated by means of the

Grashof[1] formula. The use of a steam meter and a throttling calorimeter to determine the quality of the steam would have been desirable, but these were not available at the time. Since the pressure of the steam was reduced through a valve before reaching the gauge and the needle-valve at the orifice, it was assumed that the steam was saturated at the pressures read. Under the conditions this would not be greatly in error.

Samples of the hot producer-gas were collected through a glass lined sampling tube inserted in the gas-main a short distance from the header. The tube projected into the main to a point estimated to represent the mean velocity of gas flow. The gas was collected in glass containers over water saturated with the gas. To obtain an average sample of the gas, the sampling period extended over a time of one hour, or from one firing of the producers to the next. Analyses were made by means of a portable Burrell apparatus, CO_2, O_2, unsaturated hydrocarbons (considered as C_2H_4), CO, H_2, CH_4 and N_2 (by difference) being determined. Owing to the difficulties of accurate sampling and analysis, no attempt was made to determine the soot and tar. The losses due to separation of these in their passage through the ducts to the firing chamber were therefore accounted for in the item of general losses.

The temperature of the producer-gas was measured at the point of sampling by means of a base metal thermocouple encased in an iron tube.

The temperature and humidity of the atmospheric air were determined by means of wet and dry bulb hygrometer readings.

Temperatures in the tops of the kiln chambers were measured by means of a platinum platinum-rhodium thermocouple inserted through the crown holes. These readings did not represent the average temperatures of the ware in the chambers but gave a measure of the rise in temperature during the test except in the last chamber through which the combustion gases passed. There the average rise in temperature of the ware was necessarily estimated from the data obtained.

Flue-gas samples were taken from the main draft flue near the point of delivery from the kiln. An iron sampling tube was in-

[1] Marks, "Mech. Engrs. Handbook," p. 354.

serted with the end opening at the point of approximately mean gas velocity. With the low temperatures of the flue-gases, it was considered safe to use an iron tube for this purpose. The temperature was measured at the same point with a silver-constantan thermocouple.

An attempt was made to determine the average velocity of the flue-gases in the main draft flue by means of a Pitot tube, but the manometer was not sufficiently delicate to give satisfactory readings. The volume of flue-gas was therefore calculated from its analysis, from the analysis of the producer-gas, and from the weight of coal fired.

The test covered the period of firing one chamber—forty-four hours from the time the fires were started in it until its finish and the beginning of firing in the next chamber. Data on the firing of several chambers indicated that this test might be considered as fairly representative of the kiln operation.

CALCULATIONS.

Producer.

Volume of Producer Gas.—The weight of carbon consumed per kg. of coal fired was the carbon in the coal less that in the ashes, or $0.7437 - \frac{0.1052 \times 0.0472}{0.8028} = 0.7375$.

The carbon per cu. m. of producer-gas was:

$CO_2 = 4.02\% = 0.0402$
$C_2H_4 = 0.6\% = 0.012$
$CO = 22.5\% = 0.225$
$CH_4 = 1.4\% = 0.014$

$0.2912 \times \frac{12}{22.4} = 0.156$ kg. per cu. m. of gas

$\frac{0.7375}{0.156} = 4.73$ **cu. m.** producer-gas per 1 kg. of coal fired.

Volume of Dry Air Used.—The N_2 content of the producer-gas furnished a measure of the amount of air used in the producer.

$0.6348 \times 4.73 = 3.005$ cu. m. N_2 in gas per 1 kg. of coal.

$0.0139 \times \frac{22.4}{28} = 0.011$ cu. m. N_2 in gas from kg. of coal.

2.994 = cu. m. N_2 in gas from air used per 1 kg. of coal.

$\frac{2.994}{0.79}$ = **3.79 cu. m.** dry air used per kg. of coal (at N. T. P.).

$3.79 \times 1.293 = 4.9$ kgs. dry air used per kg. of coal.

The average temperature of the atmospheric air was 17.5° C and the average moisture content was 0.00801 kg. per kg. of dry air. The total moisture entering the producer with the air was:

$$4.9 \times 0.00801 = 0.039 \text{ kg. per kg. of coal}$$

Steam Used in Producers. $M = 0.0165\ F\ p^{.97}$ (Grashof).

M = lbs. steam flowing per second.

F = area of orifice in sq. ins. = 0.0276.

p = absolute pressure of steam in lbs. per sq. in.

Multiplying M by 3600 gave the weight of steam per hour, and dividing the total for the three producers by the average weight of coal fired to the three per hour gave the weight of steam in lbs. per lb. of coal, or in kgs. per kg. of coal.

Producer 1. $M = 0.0165 \times 0.0276 \times 35.5^{.97} \times 3600 = 52.3$
Producer 2. $M = 0.0165 \times 0.0276 \times 34.4^{.97} \times 3600 = 50.7$
Producer 3. $M = 0.0165 \times 0.0276 \times 32.2^{.97} \times 3600 = 30.0$

133.0

$\frac{133.0}{468.5}$ = 0.284 lb. steam per lb. coal or kgs. steam per kg. of coal.

The moisture entering the producers from the moisture and combustion of the hydrogen in the coal was:

$$0.0258 + 0.039 \times 9 = 0.377 \text{ kg. per kg. of coal}$$

The total moisture entering the producers from all sources was:

$0.039 + 0.284 + 0.377 = 0.700$ kgs. per kg. of coal fired

Free Moisture in Producer-Gas.—The difference between the total moisture entering the producers and the moisture equivalent to the free and combined hydrogen in the gas represents the free moisture in the gas.

H_2 = 7.5% = 0.075 cu. m. H_2O vapor per cu. m. gas (at N. T. P.)
C_2H_4 = 0.6% = 0.012 cu. m. H_2O vapor per cu. m. gas (at N. T. P.)
CH_4 = 1.4% = 0.028 cu. m. H_2O vapor per cu. m. gas (at N. T. P.)

0.115

0.115 × 4.73 = 0.544 cu. m. H_2O vapor equivalent to H_2 in gas per kg. of coal, or 0.544 × 0.804 = 0.437 kg.

0.700 — 0.437 = **0.263 kg.** free moisture in gas per kg. coal fired.

Calorific Value of Producer-Gas from Analysis.

C_2H_4	= 0.6% = 0.006 ×	12915	= 77.5
CO	= 22.5% = 0.225 ×	3044	= 684.9
H_2	= 7.5% = 0.075 ×	2594	= 194.5
CH_4	= 1.4% = 9.014 ×	8558	= 119.8

1076.7 Cals. per cu. m. gas

1076.7 × 4.73 = **5095 Cals.** per kg. of coal fired.

Sensible Heat of Producer-Gas.—The average temperature of the producer-gas was 575° C. The average specific heats were obtained from the formulas of Langen.[1]

CO_2	= 4.02% = 0.0402 × (0.39 + 0.00012	× 575) × 575 =	10.6
CH_4	= 1.4 % = 0.014 × (0.34 + 0.00036	× 575) × 575 =	4.4
C_2H_4	= 0.6 % = 0.006 × (0.42 + 0.00049	× 575) × 575 =	2.4
H_2, CO / O_2, N_2	93.98% = 0.9398 × (0.31 + 0.000027	× 575) × 575 =	175.7

Sensible heat per cu. m. of dry gas = 193.1 Cals.

193.2 × 4.73 = 914 Cals. per kg. of coal fired.

0.263 kg. H_2O vapor, 0.263 × (0.44 + 0.000012 × 575) × 575 = 77 Cals.

The total sensible heat in the moist producer-gas per kg. of coal is 914 + 77 = **991 Cals.**

The total heat content of the hot producer-gas was:

5095 + 991 = 6086 Cals. per kg. of coal fired

Heat Input for Producers.—The heat content of the dry air supplied to the producers at the average temperature, 17.5° C, was:

4.9 × 0.241 × 17.5 = 20.8 Cals. per kg. of coal fired

The heat content of the moisture in the atmospheric air at average conditions was:

4.9 × 0.00801 × 604 = 23.7 Cals. per kg. of coal fired

[1] Marks, "Mech. Engr. Handbook," p. 366.

The total heat in the atmospheric air supplied was 44.5 Cals per kg. of coal.

The heat content of the steam supplied to the blowers, assuming it to be saturated at the average pressure, was:

$$0.284 \times 644 = 183 \text{ Cals. per kg. of coal fired.}$$

The calorific value of the coal was 7108 and the total heat input to the producers was $7108 + 183 + 44.5 =$ **7335 Cals.** per kg. of coal.

The Hot Gas Efficiency was $\frac{6086}{7335} =$ **82.97** per cent.

Heat Lost in Unburned Carbon in Ashes.—The amount of unburned carbon in the ashes in terms of weight of coal was:

$\frac{0.0472 \times 0.1052}{0.8028} = 0.0062$ and the heat value, $0.0062 \times 8100 =$ **50 Cals.** per kg. of coal fired.

Undetermined Heat Losses.—The heat losses due to conduction, radiation, etc., were determined by difference.

$$7335 - (6086 + 50) = 1199 \text{ Cals. per kg. of coal fired.}$$

Kiln Data.

Volumes of Flue-Gas and Air Used in Kiln.—The CO_2 from combustion of the producer-gas amounted to 2.9 per cent by volume of the flue-gas. The volume of CO_2 from the producer-gas was:

$CO_2 = 4.02\% = 0.0402$
$C_2H_4 = 0.6\% = 0.012$
$CH_4 = 1.4\% = 0.014$
$CO = 22.5\% = 0.225$

0.2912 cu. m. CO_2 per cu. m. producer-gas

$\frac{0.2912}{0.029} = 10.04$ cu. m. flue-gas per cu. m. producer-gas.

The N_2 in the flue-gas amounted to 79.3 per cent or $0.793 \times 10.04 = 7.962$ cu. m. per cu. m. producer-gas. Of this amount 0.6348 cu. m. was from the producer-gas and $7.962 - 0.6348 = 7.33$ cu. m. was from the air supplied in the kiln. The volume of air furnished was:

$\frac{7.33}{0.79}$ = 9.28 cu. m. (at N. T. P.) per cu. m. of producer-gas.

The total volume of flue-gas during the period of the test was

$$9371 \times 4.73 \times 10.04 = \textbf{445,000 cu. m.}\ \text{(at N. T. P.)}$$

The total volume of dry air supplied to the kiln was

$$9371 \times 4.73 \times 9.28 = \textbf{411,300 cu. m.}\ \text{(at N. T. P.)}.$$

The weight of moisture introduced with the air supplied to the kiln was $411{,}300 \times 0.00801 \times 1.293 = \textbf{4260 kgs.}$

Sensible Heat of Flue-Gas.—The sensible heat of the flue-gas, calculated by the use of the Langen formulas for average specific heat, was:

CO_2 $(0.029 \times 445{,}000) \times 0.21 \times 170 \times \frac{44}{22.4}$ = 1,140,000 Cals.

O_2 $(0.178 \times 445{,}000) \times 0.217 \times 170 \times \frac{32}{22.4}$ = 4,175,000 Cals.

N_2 $(0.793 \times 445{,}000) \times 0.247 \times 170 \times \frac{28}{22.4}$ = 18,530,000 Cals.

Sensible heat of dry flue-gas = 23,845,000 Cals.

The total moisture in the flue-gas from the air used in the kiln and from combustion of the producer-gas was:

$4260 + 9371 \times 0.700 = 10{,}820$ kgs. Its heat content at the average temperature of the flue-gas was $10{,}820 \times 0.46 \times 170 = 845{,}000$ Cals.

The total heat in the flue-gas was therefore 24,690,000 Cals.

Heat Used for Burning the Ware.—During the test the temperature was raised in four chambers of the kiln. The heat used in each chamber for raising the temperature of the clay was calculated separately. In one chamber the chemical water in the clay was expelled—requiring expenditure of heat—and some carbon contained in the clay was consumed. The heat from the latter was added to the other items of heat input for the kiln. In the last chamber some mechanically held moisture was expelled.

Since the temperature of the flue-gases leaving the kiln was considerably lower than that at which either the hygroscopic or chemical water in the clay was expelled, the heat content of

the steam from both sources was represented by the heat in superheated steam at the temperature of the flue-gases and at the existent vapor pressure. This value was obtained from Goodenough's steam tables.

In the case of chemically combined water, the heat required at dissociation would be that required for the endothermic reaction plus the latent heat of vaporization of steam at the dissociation temperature. In the dehydration of clay, the temperature of dissociation is above the critical temperature of water and the latent heat of vaporization would hence be zero. However, it must be considered that, in heating up the clay to the dissociation temperature, the moisture in the clay has taken up an amount of heat equivalent to the heat content of steam at the temperature and pressure existent at the point of dissociation. Hence, the use of formulas for the latent heat of vaporization of steam at dehydration temperatures of clays is not strictly correct.

Various values are given for the heat of dissociation of clay. Bleininger[1] used an assumed value of 200 Cals. per kg. of water expelled. Harrop[2] used a value, 609, from a formula given by Richards. Tschernobaeff[3] determined a value of 112 Cals. per kg. of pure kaolinite. Mellor and Holdcroft,[4] by graphical calculation from lag curves, found 42 Cals. per kg. of clay for the endothermic reaction at dehydration and 21.5 Cals. for the exothermic reaction at about 1000° C. From lag curves given by Brown and Montgomery,[5] approximate calculations gave values ranging from 757 to 1015 Cals. per kg. of water for clays having 10.7 to 13.2 per cent chemical water. As would be expected, the heat required increases with the amount of chemical water in the clay. On the basis of these data the value for the clay in this test, containing 4.65 per cent chemical water, was taken as 220 Cals. per kg. of chemical water.

The heat required to raise the temperature of the clay in the respective chambers was:

[1] A. V. Bleininger, *Trans. Am. Ceram. Soc.*, **10**, 417 (1908).
[2] C. B. Harrop, *Ibid.*, **14**, 227 (1912).
[3] D. Tschernoboeff, *Rev métal.*, **1905**, p. 729.
[4] Mellor and Holdcroft, *Trans. Eng. Ceram. Soc.*, **10**, 101.
[5] Brown and Montgomery, *Trans. Am. Ceram. Soc.*, **14**, 711 (1912).

Chamber 10.	53,320 × 2.5 × 0.23 × 210 =	6,438,000
Chamber 11.	54,560 × 2.5 × 0.23 × 300 =	9,412,000
Chamber 12.	54,560 × 2.5 × 0.23 × 180 =	5,649,000
Chamber 13.	52,080 × 2.5 × 0.20 × 300 =	9,832,000
	Heat for clay =	31,331,000 Cals.

The mechanically held water was expelled in Chamber 13, requiring 52,080 × 2.5 × 0.014 × 631.2 = 1,073,000 Cals. in the steam at the flue-gas temperature.

The chemical water was expelled in Chamber 12. The heat required for dissociation was 220 Cals. per kg. of water. The heat in the steam at the flue-gas temperature was 631.2 Cals. The heat requirement was then 851.2 Cals. per kg. of water. But the ware in Chamber 12 was at an average temperature of 300° C at the beginning of the test and the chemical water in the clay at the time was assumed to have held the heat equivalent to that of steam at the same temperature, 715 Cals. per kg. The actual amount of heat required for the chemical water was, hence, 136 Cals. per kg.

$$54{,}560 \times 2.5 \times 0.0465 \times 136 = 863{,}000 \text{ Cals.}$$

The total heat required for the ware during the test was **33,267,000 Cals.**

Heat Input for Kiln.—The heat value of the hot producer-gas, the heat in the atmospheric air supplied to the kiln, and the heat from combustion of carbon in the clay constituted the heat input.

The heat in the producer-gas was 9371 × 6086 = 57,032,000 Cals.

The heat content of the atmospheric air, as supplied to the producers, was 44.4 Cals. per 3.79 cu. m. of dry air per kg. of coal or 11.72 Cals. per cu. m., including the heat in the moisture. The air supplied to the kiln furnished 411,300 × 11.72 = 4,819,000 Cals.

The heat from the combustion of 0.25 per cent of carbon in the clay in Chamber 12 furnished 54,560 × 2.5 × 0.0025 × 8,100 = 2,762,000 Cals.

The total heat input for the kiln alone was 64,613,000 Cals., of which 33,267,000 Cals. were used for burning the ware (51,49 per cent), 26,690,000 Cals. were lost in the flue-gas (38.21 per cent)

and the balance, 6,656,000 Cals. (10.30 per cent) were charged to conduction, radiation and other undetermined losses.

Considering the kiln and producers as a unit, the total heat input from coal fired, air supplied to producers and kiln, steam supplied to the producers and carbon in the clay was 76,318,000 Cals. Of this amount, 43.59 per cent went to the burning of the ware, 32.35 per cent to the flue-gas, 8.72 per cent to heat losses from the kiln, 14.72 per cent to heat losses from the producers and 0.62 per cent loss was due to unburned carbon in the ashes. The data for the combined unit, together with the heat

FIG. 1.

HEAT BALANCE CHART.

HEAT BALANCE OF GAS PRODUCERS.

Total heat input from coal, air and steam	100 %
Heat in producer gas, calorific value plus sensible heat	82.97%
Loss due to conduction, radiation, etc.	10.35 %
Loss due to unburned carbon in ashes	0.68 %

HEAT BALANCE OF KILN

Total heat input from producer gas, air and carbon in clay	100%
Heat to raise temp. of clay and drive off water	51.49 %
Loss due to sensible heat of flue gas	38.21 %
Loss due to conduction, radiation, etc	10.30 %

HEAT BALANCE OF KILN AND PRODUCERS COMBINED.

Total heat input from coal, air, steam and carbon in clay	100%
Heat to raise temp. of clay and drive off water	43.59%
Loss due to sensible heat of flue-gas.	32.35%
Loss due to conduction, radiation, etc from kiln	8.72%
Loss due to conduction, radiation, etc from producers.	14.72 %
Loss due to unburned carbon in ashes.	0.62%

distribution for producers and kiln separately, appear on the accompanying chart.

Discussion of Results.

The data, as presented, serve as a means of comparing the heat distribution in a kiln of this type with that in periodic kilns used for similar products. As would be expected, the losses to be charged to conduction and radiation are much reduced, since a considerable amount of the heat going to the kiln structure during the firing period was recovered during the cooling—preheating the air for combustion. Hence, the percentage of the heat input which may be charged to the burning operation is much increased over that of the periodic kiln.

Of the heat charged to the heating up of the clay, the greatest portion was actually lost from the kiln by radiation and conduction and in the heat in outgoing ware. However, since it was first applied to the ware to accomplish the burning operation, it was properly charged thus.

Although the temperature of the outgoing flue-gas was very low, the large excess of air admitted to the kiln resulted in a large volume of flue-gas and, consequently, a large loss of heat in the flue-gas. If some means of regulating the amount of air admitted were applied, this loss could be materially reduced.

It would be of interest to determine the actual amount of heat lost from the kiln structure itself and that remaining in the burned ware and which escaped to the atmosphere by circulation of the air through the cooling chambers and through the openings in the crown and the doorways. Considerable difficulty would have been encountered in obtaining the necessary data for this purpose.

In conclusion, the writer desires to express his indebtedness to Prof. C. W. Parmelee for his able assistance in carrying out the tests, to Mr. C. W. Parks who assisted in obtaining some of the data, and to the Baker Clay Company and the International Clay Machinery Company for their coöperation in the work.

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SOME FACTORS INFLUENCING THE TIME OF SET OF CALCINED GYPSUM.[1]

By F. F. Householder.

Introduction.

The time of of set calcined gypsum is one of its very important properties. Several methods for its measurement have been suggested and the chief ones have been tested and rated according to their merits.[2] However, no data resulting from thorough work on the relation of the time of set to the other physical properties is available. Obviously, this relation will depend upon the purity of the gypsum from which the plaster is made, the temperature at which it is calcined, and the amount of retarder or accelerator added. Experience shows that it also depends upon the cleanliness of the boxes or vessels in which the plaster is mixed, and the purity of the water used.

This preliminary note describes some tests made in order to determine the effect of varying the consistency of the mixtures, the time of stirring, the rate of stirring, and the temperature of the water used in mixing, on the time of set of calcined gypsum. The tests reported—although they may be of some value in themselves—were made as a guide in outlining further and more extensive tests on the physical properties of gypsum.

Preparation of Samples.—The same grade of plaster was used (without the addition of any retarder or accelerator) throughout the whole series of tests. A sample of 300 g. was made up in each case in a clean casserole. Each sample was stirred by means of a small spatula—kept well polished. The plaster was added to the water as rapidly as possible (4 to 5 seconds) without splashing or waste and allowed to stand undisturbed for one minute. It was then poured (or was stirred as the test demanded and then poured) into the standard mold of a Vicat[3] apparatus. The

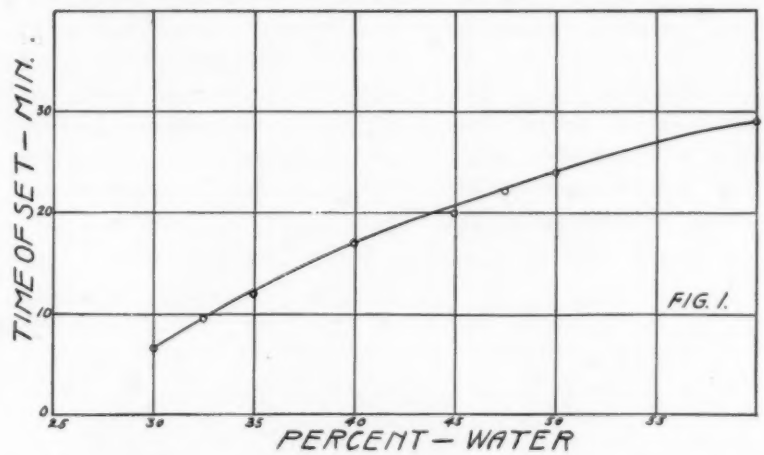
[1] By permission of the Director, Bureau of Standards.

[2] Emley, *Trans. Am. Ceram. Soc.*, **19**, 573–584.

[3] 1915 Year Book, A. S. T. M., p. 359.

mold was thoroughly cleaned before each test and covered with a very thin coating of oil. The time of set was determined, as suggested by Emley,[1] by means of the standard Vicat needle.

Effect of Per cent Water Added.—To determine the effect of the amount of water used in mixing the plaster, on the time of set, samples containing 30, 32 1/2, 35, 37 1/2, 40, 42 1/2, 45, 47 1/2, 50 and 60 per cent of water, respectively, were made up and tested. A large number of tests on each mixture were made and the average results at each percentage plotted. In Fig. 1 is shown the variation in the time of set with the amount of water



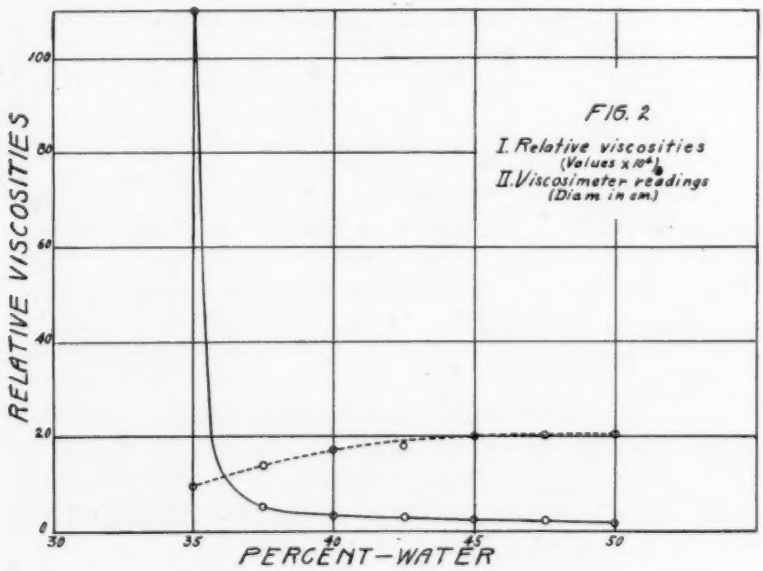
used in the mixtures. The samples containing 30 per cent water were so stiff and viscous that much care and effort were required in introducing them into the mold. However, the time of set of the individual samples did not vary from the average by more than one-half minute. The sample containing 32 1/2 per cent water was too viscous to mold satisfactorily, but gave fairly uniform values.

The curve (Fig. 1) shows a fairly uniform increase in the time of set as the percentage of water was increased until about 45 per cent was reached. Then the increase in time of set was less rapid—due to the fact that when the mixture was poured into

[1] See page 578, *Loc cit.*, **19**, 583-4.

the mold the plaster settled to the bottom and the excess water came to the top. A thin film of water came to the top of the $47^1/_2$ per cent sample, and in the case of the 50 per cent sample, a layer of water 1–1.5 mm. deep formed, while with the 60 per cent sample, the water was 7 mm. deep at the top of the mold. Evidently, before any setting had taken place, the mixture was reduced to about 47 or 48 per cent water and the further retardation was probably due, in part at least, to the fact that the plaster was under water. Also, the layer of water at the top of the mold increased the penetrating ability of the needle. These samples did not harden at the top—not even after the pouring off of the water and their removal from the mold. A day or two later the top could be brushed away with the hand. Considering the samples containing from 30 to 45 per cent water, an increase in the time of set from 6.5 minutes to 20 minutes, or approximately 300 per cent, is noted, while in the 45 to 60 per cent samples it increases from 20 minutes to 29 minutes or approximately 50 per cent.

Viscosity Measurements.—The relative viscosities of each of the samples was determined by means of the Southard viscosi-



meter. The samples from 35 per cent up were placed in the viscosimeter and gave the results shown by the dotted curve (Fig. 2.). Assuming that the "patties" were circular, the viscosity of a mixture would vary inversely as the square of the diameter of the "patty." The relative viscosities are shown by the solid curve (Fig. 2). A very marked decrease is noted between the water contents of 35 and 40 per cent but not much change is noted thereafter. The instrument used was not water tight and hence the 60 per cent sample was not tested. The shape of the viscosity curve would indicate that the viscosity very rapidly approaches that of water and probably reaches it before it crosses the 100 per cent abscissa. Lack of data makes it unsafe to judge where the two curves meet.

No extensive work has been published on the properties of gypsum solutions, although investigations along this line may lead to a more satisfactory definition of normal consistency. The immediate results obtained here indicate, that decreasing the viscosity increases the time of set, but that the relation between the two is not a simple function.

Effect of Stirring.—In determining the effect of continued stirring, the samples used were mixed with 40 per cent water and each was stirred with a small spatula at the rate of four strokes per second. The calcined gypsum was added to the water and the mixture allowed to stand one minute, as before. The first sample was then poured immediately into the mold and the time of set determined. Each of the others was stirred at the same rates for 0, 0.5, 1, 2, 3, and 4 minutes, respectively, and then poured into the mold. In Fig. 3 is shown the results of the tests. Continuous stirring for four minutes decreases the time of set from

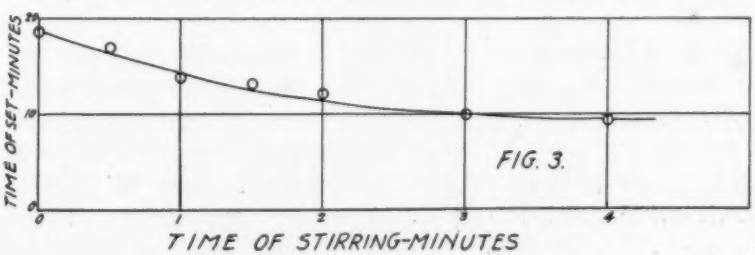
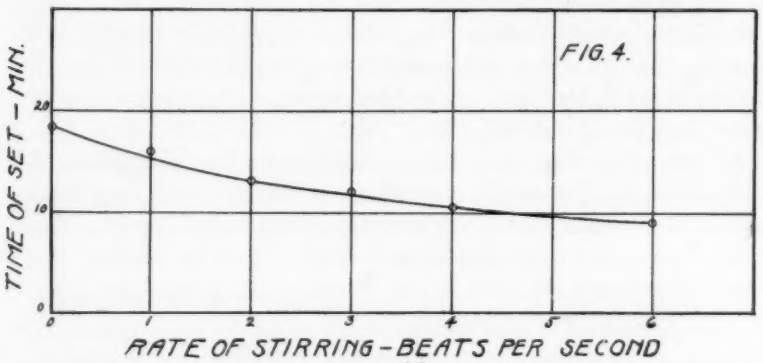


FIG. 3.

18.5 minutes (with no stirring) to 9.5 minutes or to almost one-half. The general shape of the curve would indicate that the time of set would not be very greatly decreased by a continuation of the stirring.

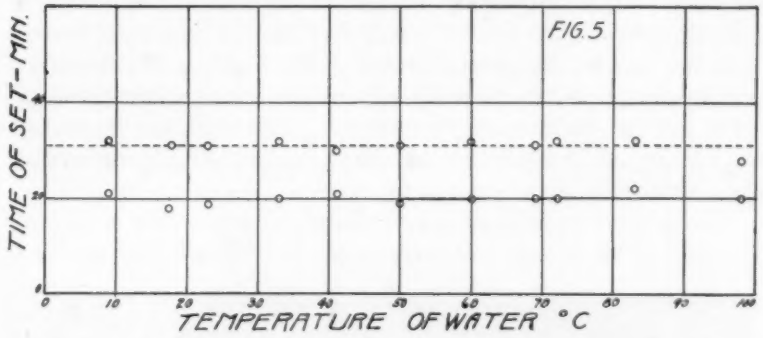
In Fig. 4 is shown the effect of varying the speed of stirring of the same kind of samples on the time of set. The stirring was all done by hand and the speed varied from 0 to 6 strokes per second (each sample being stirred for one minute only). In-



creased speed of stirring reduced the time of set. The shape of this curve is very similar to that of the curve shown in Fig. 3, although the decrease in the time of set is not so marked. The increased agitation of the mixture—either by increased stirring or by more rapid stirring—hastened the time of set. The first effect is probably to increase the rate at which the dry plaster takes up the water and goes into solution. The first crystal clusters formed are probably broken up and distributed throughout the mixture—thus becoming nuclei for further crystallization.

Effect of Temperature.—The effect of heating the water before mixing with the plaster was also tried out. The samples used for this purpose contained 40 per cent water and each was stirred at the same rate and for the same time as before. The data secured is less uniform than that secured in the foregoing experiments, but does not vary in any given direction. The conclusion reached is, that the temperature of the water has no appreciable

effect on the time of set. The setting of calcined gypsum is always accompanied by an evolution of heat (pure $CaSO_4\ ^1/_2H_2O$ in forming $CaSO_4 2H_2O$ giving up about 3700 cal. per gram molecular weight). Heating would therefore tend to retard the process were it kept confined. On the other hand, the solubility of calcined gypsum tends to increase with a rise in temperature of the water—which would probably induce an acceleration of the process. Evidently, from the results of this test, the two factors mentioned would about balance each other.



By the heavy curve (Fig. 5) is shown the time of set as determined by this test. The dotted curve shows the points at which the needle did not penetrate at all, or the time of hardening of the gypsum. The same regularity that is seen in the time of set is shown here.

Conclusions.

1. Increasing the proportion of water causes a decrease in viscosity and an increase in the time of set of calcined gypsum.

2. Vigorous and continuous agitation, when mixing the calcined gypsum with the water, tends to decrease the time of set.

3. The temperature of the water used in mixing has no influence on the time of set.

The above experiments were the outcome of the suggestions of Mr. C. A. Birdsley, Chief Engineer; P. H. Butler, Supt.; and J. A. Davis, of the Oakland Plant of the U. S. Gypsum Co. Acknowledgments are also due Mr. F. A. Kirkpatrick for many valuable suggestions in making the experiments.

THE NATURE OF THE AIR CONTENT OF PUGGED CLAYS.

By H. Spurrier.

As a sequel to some work done on the quantitative measurement of the air content of pugged clays, the question arose as to the composition of such air after imprisonment for a greater or less period in the clay body. A preliminary analysis of the liberated and collected gases gave an oxygen content of 7 per cent as against a normal oxygen content in free air of about 21 per cent.

At the time of this determination, it was not possible to secure a large enough sample to make a complete analysis that could be relied upon as thoroughly trustworthy. Recently, a very simple scheme (Fig. 1) was devised to secure any desired amount of the gas occluded in clay.

A large glass funnel was inverted and equipped with a tube of 30 millimeters internal diameter, suitably drawn out at both

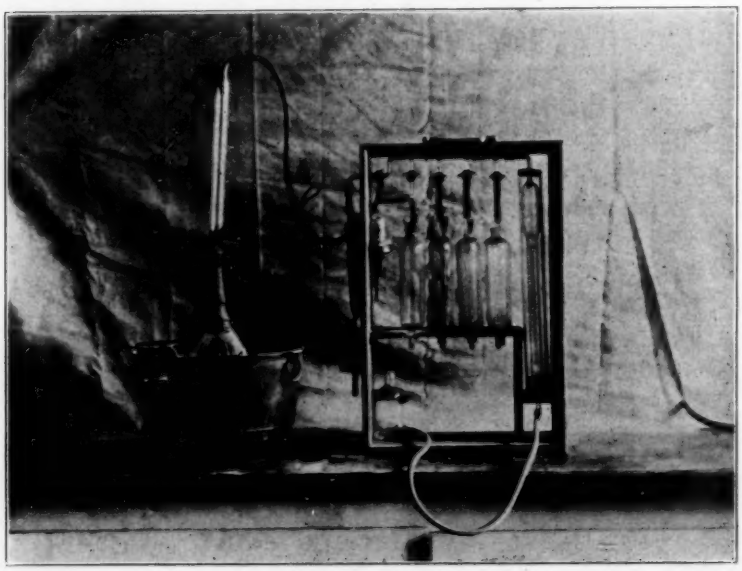


Fig. 1.

ends. The upper end was bent at a right angle and a gas-tight joint was made at the lower end between the tube and the inverted funnel. The funnel was then partly immersed in water contained in a large iron kettle. The water was boiled for a considerable time to eliminate dissolved gases, allowing steam to issue at the upper end for about 15 minutes. The screw-cock at "A" was then closed and the flame lowered till the water was just at the boiling point. The tube "B," on cooling, filled itself completely with water—proving the expulsion of the air.

Clay blanks which had been pugged about 24 hours previously were then slipped under the funnel; as the blanks disintegrated, the contained air was liberated—rising to the top of the tube "B." This was continued until a sufficient quantity of the gases had been collected.

The transfer and analysis of the gases needs no description. The following analysis represents the collected gases:

	Per cent.
Carbon dioxide	3.85
Oxygen	13.46
Carbon monoxide	1.92
Nitrogen	80.77
	100.00

As is well known, if a bituminous coal is kept in a confined atmosphere, it will extract nearly all of the oxygen therefrom. As no further work has as yet been done, it would be somewhat hazardous to draw any conclusions as to what might be called the secondary effects of the change made obvious by the analysis. The aim of the present note is to bring the matter to your attention and to stimulate other workers in this direction. There are indications that the change is not quite so simple as at first sight might seem apparent, and that further investigation of the phenomenon might not be barren of results of practical importance.

It is obvious, of course, that these chemical changes are intimately connected with the well-known physical changes that take place during the ageing and weathering of clays. Some light might, in this way, be thrown upon the much studied and as yet imperfectly understood question of plasticity.

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ACTIVITIES OF THE SOCIETY.

This department has been established by the Publication Committee, at the request of the President, in order to keep the membership in general informed of the activities of the officers, the Board of Trustees, and the several committees of the Society. This will be the official avenue of appeal to the membership for coöperation in the work of the Board and committees. Reports of the various Local and Student Sections will be published here and also accessions to membership, notice of death of members and other items of Society news. No personal items, unless they are also distinctly Society news, will be printed.

Next Annual Meeting.

The Board of Trustees has voted that the next annual meeting shall be held at the Fort Pitt Hotel, Pittsburgh, Pa., on February 3rd, 4th and 5th. Details will be published later.

Resolutions Passed by the Board.

Professional Divisions may be formed in the following ways:

1. "When the initiative in the formation of Divisions is taken by members who are interested, a petition may be presented by not less than ten members in good standing, of whom three or more shall be Active, who are interested especially in some phase of ceramic work sufficiently broad to warrant the formation of a special Division. This petition shall go to the President who shall then appoint a representative committee to consider the advisability of forming such a Division, and to proceed with the organization if the decision is favorable."

2. "When the intiative is taken by the Board of Trustees in order to stimulate the growth of the Society, the President shall appoint a representative man to furnish the initiative. He shall select his own committee."

The Board has passed a resolution to the effect:

"That fifty copies of each issue of the JOURNAL shall be assigned to the order of the Chairman of the Membership Committee, the number to be subject to reduction by the Board if the results do not seem to justify the expense."

Motions Pending.

Motion by Mr. Montgomery, for immediate decision:

"That the President shall appoint a representative individual for each Division to be organized, who shall select his own committee as provided in Section 2, of the motion recently passed by the Board for this purpose, and that these committees shall proceed to organize the following Divisions before our meeting in February:

1. Glass Division.
2. Enamel Division.
3. Pottery or White Ware Division, including porcelain.
4. Refractories Division.
5. Structural Clay Products Division.

With motion, by the President, to amend by striking out

5. Structural Clay Products Division

and adding:

5. Brick and Tile Division, including brick, hollow-tile and drain-tile.
6. Terra Cotta and Faience Division.
7. Abrasive Division."

Motions by the President, for decision December 20th.

1. "That the Committee on Publications be instructed to complete as soon as possible the "Index of the Transactions of the American Ceramic Society" and to submit to the Board of Trustees an estimate of the cost of publishing same."

2. "That no Local Section, Student Section or Division shall have the right to assess Section or Division dues against members of the parent Society, unless such members have signified their desire in writing to be considered members of said Section or Division."

3. "That, as of the date of November 1, 1918, fifty (50) copies of each volume of the Transactions be reserved for sale in complete sets only, and that the Secretary be instructed to purchase, at five dollars ($5.00) each, sufficient copies to bring the total stock of each volume to that figure."

4. "That two hundred (200) copies of each number of the Journal be reserved at the time of issue for sale in complete sets only, and that an additional two hundred (200) copies be likewise reserved for sale in complete volumes only. Futhermore, that it is the sense of this resolution that a 'complete set' shall consist of the first five volumes of the Journal and such additional volumes as shall have been issued up to the date of the sale, and that a 'sale' shall be the actual selling of volumes and not the furnishing of them in consideration of payment of membership dues."

5. "That copies of the volumes of the Transactions and of the Journal shall be furnished to members who have or shall allow their dues to become delinquent only after the number reserved for sale has been provided. Furthermore, that in cases in which the volume that should be furnished in considera-

tion of a certain year's dues is not available, the member shall have the option of selecting any available volume or having the dues apply to the succeeding year."

Full discussion by the membership and suggestions in regard to these resolutions is desired by the Board. Any communications sent to the President or Secretary will be transmitted to the other members of the Board. They will not be published here. The President desires suggestions as to proper persons to appoint for the organization of the various Divisions.

ACQUISITION OF NEW MEMBERS DURING NOVEMBER, 1918.

Associate.

Frederick K. Minor, Celite Products Co., Pittsburgh, Pa.
John W. Yuill, Hercules Powder Co., Nitro, W. Va.
G. F. Dufour, Y. M. C. A., Hamilton, Ohio.
Melville Marks, Moore & Munger, New York, N. Y.
Dr. A. Bigot, 112 Avenue de Suffren, Paris, France.

Contributing.

Champion Ignition Company, Flint, Michigan.

LOCAL SECTION MEETINGS.

NORTHERN OHIO SECTION.

A joint meeting of the Northern Ohio Section of the American Ceramic Society and the Cleveland Section of the American Chemical Society was held in the Hotel Olmstead, Cleveland, Ohio, on December 9, 1918. The following program was afforded at the afternoon and evening sessions:

CERAMIC SECTION—AFTERNOON MEETING—3.00 P.M.

"Ceramic Features of the Chemical Exposition," by W. M. Clark, National Lamp Works, Cleveland, Ohio.

"Observations on the Apparent Cause of Failure of Lead-Glass Pots," by A. F. Gorton, Buckeye Clay Pot Co., Toledo, Ohio.

Discussion—"After-War Adjustments of the Ceramic Industries."

Business Session—By-laws and other important matters relative to the Local Sections.

CHEMICAL AND CERAMIC SECTIONS—JOINT MEETING—8.00 P.M.

"Refractory Materials as a Field for Research," by Dr. E. W. Washburn, National Research Council, Washington, D. C.

The meeting was a successful one in every way. It was better attended and even more interesting than the previous meetings which the Northern Ohio Section has held.

The paper by Mr. W. M. Clark was a very able review of the Ceramic features of the Chemical Exposition together with certain exceedingly interesting conclusions which Mr. Clark drew therefrom.

The paper by Dr. Gorton on "Causes of Failure of Lead-Glass Pots" was very instructive and promises to be of interest to readers of the Journal.

Mr. Stowe, in a paper on "Magnesite" (not mentioned in the formal program), ably discussed the recent developments in this important branch of the refractories industry.

The paper by Dr. Washburn at the joint meeting in the evening was a very interesting presentation of some of his impressions and findings as a member of the National Research Council. This paper will be published in an early number of the Journal.

R. D. LANDRUM, *Secretary*,
Cleveland Section,
American Chemical Society.

B. A. RICE, *Secretary*,
Northern Ohio Section,
American Ceramic Society.

NEW JERSEY CLAY WORKERS' ASSOCIATION.

A well attended meeting of the New Jersey Clay Workers Association was held at Rutgers College, New Brunswick, N. J., on December 17th. The following program was afforded at the morning and afternoon sessions:

MORNING SESSION.

"Some Defects in Terra Cotta," by D. F. Albery, Federal Terra Cotta Co., Woodbridge, New Jersey.

"Sagger Mixtures," by Prof. G. H. Brown, Department of Ceramics, Rutgers College, New Brunswick, New Jersey.

"The Effect of Some Fluxes in Porcelain," by F. H. Riddle, Bureau of Standards, Pittsburgh, Pa.

AFTERNOON SESSION.

"Fuel Combustion," by Henry Kreisinger, Fuel Section of the U. S. Bureau of Mines, Pittsburgh, Pa.

"Future Kiln Developments," by Prof. Carl B. Harrop, Department of Ceramic Engineering, Ohio State University, Columbus, Ohio.

"Solving One of the Clay Manufacturers Greatest Problems," by Mr. Paul D. March, Philadelphia Textile Machinery Co., Philadelphia, Pa.

The New Jersey Clay Workers Association will apply for a charter as a Local Section of the American Ceramic Society at the annual meeting of the Society in February.

The Journal of the American Ceramic Society

THIS JOURNAL, the official organ of the American Ceramic Society, appears at this time to fill a need of the American Ceramic Industries.

It is to be published monthly, and for this reason embraces a wider field of activity than the volumes of the Transactions which it succeeds, and thereby offers greater opportunities of service to Ceramic Science and Industry.

The success of this Journal will depend upon the efforts of the individual members. Your contributions, your discussions and your suggestions, are necessary; but above all, your assistance in securing new members for the Society and subscribers to the Journal is of prime importance. The Committee on Publications therefore requests that each member of the Society be personally responsible for securing all possible members and subscriptions in his own city or town.

The subscription price is—$6.00 per year to non-members.

The annual membership dues of the Society, five dollars per year, include subscription to the Journal.

The public library, the librarians of the nearby universities, colleges or other institutions, as well as individuals who are, or ought to be, interested in the work of your Society are your objectives.

Use the application blanks at the bottom of this sheet for enrolling members and subscribers. Applications should be mailed to Prof. Charles F. Binns, Alfred, N. Y.

Complete and energetic support on the part of the membership will insure a conspicuous success for our new publication.

COMMITTEE ON PUBLICATIONS.

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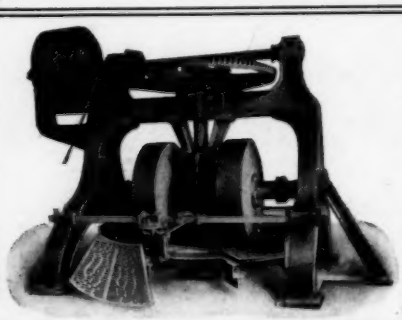

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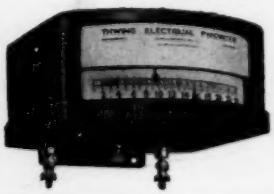

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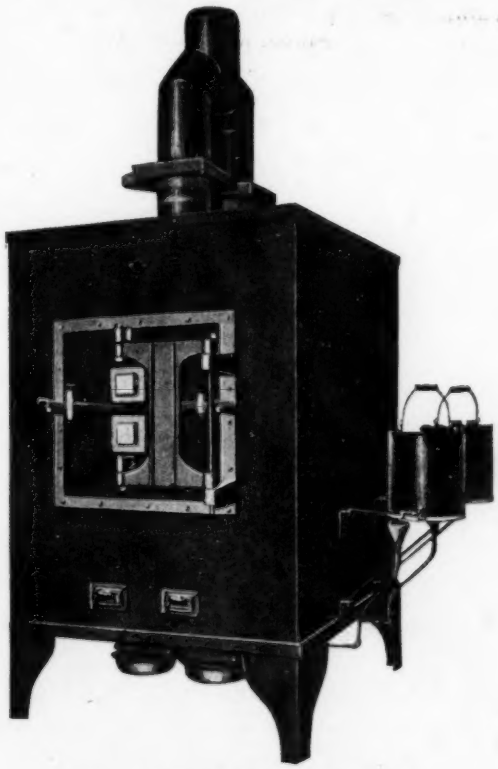

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